

15.0 PERMITTING GUIDANCE

This section provides guidance to permit writers and control authorities (e.g., POTWs) in implementing the MP&M effluent guidelines. In particular, this section provides permit writers and control authorities with information and data that can be useful in converting concentration-based limitations to mass-based limitations. As explained later in this section, EPA is not proposing mass-based limitations for any of the MP&M subcategories except for the Steel Forming and Finishing Subcategory. However, EPA recommends that permit writers or control authorities evaluate a facility's water use and develop mass-based limits in cases where a facility does not have sufficient water conservation practices in place. This section provides permit writers and control authorities with the tools to assess a facility's water conservation practices.

The MP&M category covers sites that generate and discharge wastewater while manufacturing, assembling, rebuilding, repairing, and maintaining metal parts, metal products, and machinery for use in one or more of the following industrial sectors: aerospace, aircraft, bus and truck, electronic equipment, hardware, household equipment, instruments, job shops, mobile industrial equipment, motor vehicles, office machines, ordnance, precious metals and jewelry, printed wiring boards, railroad, ships and boats, stationary industrial equipment, and miscellaneous metal products. The MP&M category includes state and local government facilities that manufacture, maintain, or rebuild metal parts, products, or machines (e.g., a town that operates its own bus, truck, and/or snow removal equipment maintenance facility). MP&M effluent guidelines also cover federal facilities or other mixed-use facilities that manufacture, maintain, or rebuild metal parts, products or machines (e.g., U.S. naval shipyards).

EPA is proposing limitations and standards for 8 subcategories of facilities (covering all 18 industrial sectors). Section 6.0 of this document discusses the proposed subcategorization scheme.

Section 15.1 provides background on the MP&M effluent guidelines. Section 15.2 provides basic guidance on implementing the MP&M effluent guidelines. Sections 15.3 through 15.6 present guidance on determining pollution prevention and water conservation practices for the major wastewater-generating unit operations performed at MP&M sites. Tables 15-1 through 15-9 and all figures are located at the end of the section.

15.1 Background

EPA has established effluent guidelines for 13 industrial categories that may perform operations that are sometimes found in MP&M facilities. These effluent guidelines are:

- C Electroplating (40 CFR Part 413);
- C Iron & Steel Manufacturing (40 CFR Part 420);
- C Nonferrous Metals Manufacturing (40 CFR Part 421);
- C Ferroalloy Manufacturing (40 CFR Part 424);

- C Metal Finishing (40 CFR Part 433);
- C Battery Manufacturing (40 CFR Part 461);
- C Metal Molding & Casting (40 CFR Part 464);
- C Coil Coating (40 CFR Part 465);
- C Porcelain Enameling (40 CFR Part 466);
- C Aluminum Forming (40 CFR Part 467);
- C Copper Forming (40 CFR Part 468);
- C Electrical & Electronic Components (40 CFR Part 469); and
- C Nonferrous Metals Forming & Metal Powders (40 CFR Part 471).

In 1986, the Agency reviewed coverage of these regulations and identified a significant number of metals processing facilities discharging wastewater not covered under these 13 regulations. Based on this review, EPA performed a more detailed analysis of these unregulated sites and identified the discharge of significant amounts of pollutants. This analysis resulted in the formation of the “Metal Products and Machinery” (MP&M) category.

EPA recognizes that, in some cases, unit operations performed in industries covered by the existing effluent guidelines are the same as unit operations performed at MP&M facilities. In general, when unit operations and their associated wastewater discharges are already covered by an existing effluent guideline, they will remain covered under that effluent guideline. However, many facilities that are covered by the existing Electroplating (40 CFR 413) and Metal Finishing (40 CFR 433) effluent guidelines will now be covered by MP&M. EPA notes that the proposed MP&M rule amends the applicability of 40 CFR Parts 413, 433, 464, 467 and 471 to clarify coverage as it relates to facilities covered by the MP&M rule. Section 1 discusses the applicability of the MP&M rule, including the overlap with existing regulations.

When a facility covered by an existing metals effluent guideline (other than Electroplating or Metal Finishing) discharges wastewater from unit operations not covered under that existing metals guideline but covered under MP&M, the facility will need to comply with both regulations. In those cases, the permit writer or control authority (e.g., POTW) will combine the limitations using an approach that proportions the limitations based on the different production levels (for production-based standards) or wastewater flows (for concentration-based standards). POTWs refer to this approach as the “combined wastestream formula” (40 CFR 403.6(e)), while NPDES permit writers refer to it as the “building block approach.” Application of the combined wastestream formula can be found in EPA’s Guidance Manual For the Use of Production-Based Pretreatment Standards and the Combined Wastestream Formula (24). Other references which can be used by the permit writer or control authority include EPA’s Guidance Manual for Electroplating and Metal Finishing Pretreatment Standards (25), and EPA’s NPDES Permit Writers’ Manual (26). Section 15.2 discusses the combined wastestream formula in more detail. In addition, Section 15.2 discusses several monitoring alternatives which EPA has proposed to reduce burden on MP&M facilities.

As discussed in Section 14.0, the MP&M effluent limitations guidelines and standards consist of concentration-based limitations for seven subcategories and mass-based limitations for one

subcategory. EPA defines the MP&M subcategories in Section 6. Concentration-based limits apply to the following dischargers:

- C Existing and new direct and indirect discharging Printed Wiring Board subcategory facilities;
- C Existing and new direct and indirect discharging Metal Finishing Job Shops subcategory facilities;
- C Existing and new direct discharging Railroad Line Maintenance subcategory facilities;
- C Existing and new direct discharging Shipbuilding Dry Dock subcategory facilities;
- C Existing and new direct discharging Non-Chromium Anodizing subcategory facilities;
- C Existing and new direct discharging General Metals subcategory facilities;
- C Existing and new indirect discharging General Metals subcategory facilities with flows greater than one million gallons per year of process wastewater;
- C Existing and new direct discharging Oily Waste subcategory facilities; and
- C Existing and new indirect discharging Oily Waste subcategory facilities with flows greater than two million gallons per year of process wastewater.

Mass-based limitations apply to:

- C Existing and new direct and indirect discharging Steel Forming and Finishing subcategory facilities.

EPA is proposing mass-based limitations (instead of concentration based limitations) for direct and indirect discharging Steel Forming and Finishing subcategory facilities for several reasons. First, NPDES regulations (40CFR Part 122.45(f)) require permit writers to implement mass-based limits for direct dischargers and the General Pretreatment Standards (40CFR Part 403.6(d)) provides that the control authority may impose mass-based limitations on industrial users when appropriate. In the case of facilities in the Steel Forming and Finishing subcategory, EPA already regulates wastewater discharges from these facilities under 40CFR Part 420 using mass-based limits. As a result, these facilities are already accustomed to tracking their production rate (i.e., tons of product produced per day). Because of the uniform nature of the steel products produced by Steel Forming and Finishing facilities (wire, rod, bars, pipe, or tube), facilities in this subcategory can track the weight of product produced in a relatively straight forward manner. One of the primary reasons that EPA is not proposing mass-based limitations for other subcategories is the fact that most MP&M facilities do not collect production information on a wastestream-by-wastestream basis, and therefore development of mass-based limitations could create a significant burden for the permit writer, control authority, and the MP&M facility. (See Section 15.2.3 for a discussion on implementing the Steel Forming and Finishing mass-based limits).

The following facilities are excluded from this regulation: existing and new indirect dischargers from the General Metals Subcategory that discharge less than or equal to one million gallons per year of process wastewater; existing and new indirect dischargers from the Oily Wastes Subcategory that discharge less than or equal to two million gallons per year of process wastewater; existing and new indirect discharging Railroad Line Maintenance subcategory facilities; existing and new indirect discharging Shipbuilding Dry Dock subcategory facilities; and existing and new indirect discharging Non-Chromium Anodizing subcategory facilities. Existing and new indirect discharging Non-Chromium Anodizing subcategory facilities remain covered by the electroplating (40 CFR Part 413) and metal finishing (40 CFR Part 433) effluent guidelines, as applicable.

As mentioned above, EPA is not proposing that permit writers or control authorities implement the MP&M limits on a mass basis except for the Steel Forming and Finishing Subcategory. However, EPA recommends that permit writers or control authorities evaluate a facility's water use and develop mass-based limits when a facility does not have sufficient water conservation practices. At 40 CFR 122.45(f), EPA requires permit writers to implement mass-based limitations for direct dischargers, but the NPDES regulations allow an exception when the limits are expressed in terms of other units of measurement (e.g., concentration). Section 403.6(d) of the CWA provides that the control authority may impose mass-based limitations on industrial users which are using dilution to meet applicable pretreatment requirements or where mass-based limitations is appropriate. Sections 15.3 through 15.6 provide permit writers and control authorities with the tools to assess a facility's water conservation practices.

For MP&M facilities that have good water conservation practices, the concentration-based effluent limitations may be sufficient. Sections 15.3 through 15.6 provide the permit writer or control authority with methodologies to determine if sites are complying with the concentration-based effluent limits without increasing process water usage (i.e., dilution). For MP&M facilities that do not have good water conservation practices, the permit writer or control authority can use the information provided in this section to develop mass-based limitations. EPA believes that this approach will reduce the implementation burden associated with establishing mass-based limitations for all MP&M facilities, and will still increase use of water conservation practices at the facilities where it is most appropriate. EPA anticipates that MP&M facilities that have been using the best pollution prevention and water conservation practices may request that the permit writer or POTW use mass-based limits in their permits.

EPA based the proposed concentration-based MP&M effluent limitations on a technology train consisting of in-process pollution prevention and flow-reduction technologies followed by end-of-pipe treatment. The in-process technologies include: conductivity meters, flow restrictors, and countercurrent cascade rinsing for flowing rinses; at-the-source machine coolant recycling; and at-the-source paint curtain recycling. The end-of-pipe treatment for the five metal-bearing subcategories include pretreatment steps such as chromium reduction, cyanide destruction, oil/water separation, and chelated metals treatment, followed by chemical precipitation with solids removal. The end-of-pipe treatment for the Oily Wastes Subcategory is

chemical emulsion breaking and oil water separation and the end-of-pipe treatment for the Railroad Line Maintenance and Shipbuilding and Dry Docks Subcategory is dissolved air flotation. Section 9.0 discusses in detail the treatment technology options for various subcategories. EPA's effluent limitations guidelines and standards do not require that a discharger (or POTW industrial user) install any prescribed treatment system to comply with the limitations and standards. Facility operators are free to choose any mechanism or combination of treatment options they wish, including sending process wastewater off-site for treatment, so long as the operator does not discharge (or introduce to a POTW) wastewater in violation of EPA's limitations and standards.

EPA is proposing to establish a three-year deadline (from the date of publication of the final MP&M rule) for compliance with the MP&M pretreatment standards for existing sources (PSES). EPA is proposing a three-year deadline because design and construction of systems adequate for compliance with PSES will be a substantial undertaking for many MP&M sites. In addition, control authorities (e.g., POTWs) will need the time to develop the permits or other control mechanisms for their industrial users. Once EPA finalizes the MP&M rule, these limitations will be reflected in NPDES permits issued to direct dischargers. New sources must comply with the new source standards and limitations (PSNS and NSPS) of the MP&M rule (once it is finalized) at the time they commence discharging MP&M process wastewater. Because the final rule is not expected within 120 days of the proposed rule, the Agency considers a discharger a new source if its construction commences following promulgation of the final rule (40 CFR 122.2; 40 CFR 403.3). In addition, the current MP&M proposal notice fully replaces the MP&M Phase I proposal, published on May 30, 1995. Therefore, compliance deadlines in that proposal would obviously no longer apply.

15.2 Implementing the MP&M Effluent Guidelines

Once the permit writer or control authority determines applicability and the appropriate subcategory for a site (see Section 6), EPA suggests that the permit writer or control authority conduct a process-water-use analysis to determine if the site currently implements sufficient pollution prevention and water conservation practices. Figure 15-1 outlines the decision making steps for the process-water-use analysis. EPA defines process wastewater as any water that, during manufacturing, rebuilding, or maintenance, comes into direct contact with or results from the production or use of any raw materials, intermediate product, finished product, by-product, or waste product. The Agency does not consider noncontact cooling water a process wastewater. However, it does consider wastewater from the operation of air pollution control equipment used in MP&M process areas process wastewater. (See Section 1.3 for a discussion of the applicability of wastewater streams.)

Section 15.2.3 describes the use and appropriateness of historical flow data to calculate mass-based limitations while Section 15.2.4 describes the use of EPA's flow data from MP&M surveys to develop mass-based limits. The Agency recommends that the permit writer or control authority use historical flow data only when converting concentration-based limits for a site that has demonstrated pollution prevention and water conservation practices in place (e.g.,

on-demand countercurrent cascade rinses, in-process metal recovery, recycling of machining coolants) for unit operations contributing most of the site's flow. A site with good pollution prevention and water conservation practices may request that their discharge permit or control mechanism contain mass-based limits. Section 15.2.7 discusses several proposed flexible monitoring alternatives that are expected to reduce burden. Sections 15.3 through 15.6 discuss examples of common pollution prevention and water conservation practices applicable to the major wastewater-generating MP&M operations. These sections also provide information for assessing the performance of these practices at MP&M sites.

Unit operations typically contributing the majority of the flow from a MP&M site are:

- C Surface treatment rinses (e.g., acid and alkaline treatment rinsing, electroplating rinsing, anodizing rinsing, and chemical conversion coating rinsing);
- C Machining operations;
- C Painting operations; and
- C Cleaning operations.

These operations produce approximately 77 percent of the wastewater generated by MP&M sites. EPA estimates that approximately 96 percent of the 10,300 MP&M wastewater-discharging sites perform one or more of these operations. For facilities that do not have sufficient pollution prevention and water conservation practices in place, EPA recommends that the permit writer or control authority use best professional judgment (BPJ) when converting from the concentration-based limits to mass-based limits. Sections 15.2.4 and 15.3 contain information that will be helpful in using BPJ for this purpose.

15.2.1 Application of the Building Block Approach for Direct Dischargers

For instances where a direct discharger is covered by multiple categorical standards (e.g., MP&M, Iron and Steel - 40 CFR Part 420, and Aluminum Forming - 40 CFR Part 467) or multiple subcategories¹ within MP&M, the NPDES permit writer must apply the limits from each categorical standard (and/or MP&M subcategory) to derive the effluent limits for the facility. If a facility combines all wastewater regulated by the various effluent guidelines prior to treatment or discharge to surface waters, then the permit writer would combine the allowable pollutant concentrations or loadings for each subcategory (proportioning the flow or load appropriately) to arrive at a single, combined set of technology-based effluent limits for the facility - the “building block” approach (24). In circumstances where a facility combines a wastestream for which a particular pollutant is not regulated by the applicable categorical standard with another wastestream for which the pollutant is regulated, then the permit writer must ensure that the stream that does not contain the regulated pollutant does not dilute the stream containing the regulated pollutant to the point where the pollutant is not analytically detectable. If this occurs, then federal regulations at 40 CFR Part 122.45(h) authorize the permit writer to establish internal monitoring points.

¹ EPA notes that if a facility that has wastewater that falls under the Oily Wastes Subcategory and wastewater under the General Metals Subcategory the facility would be covered by the General Metals limits only, unless the site treats the wastewater in separate wastewater treatment systems.

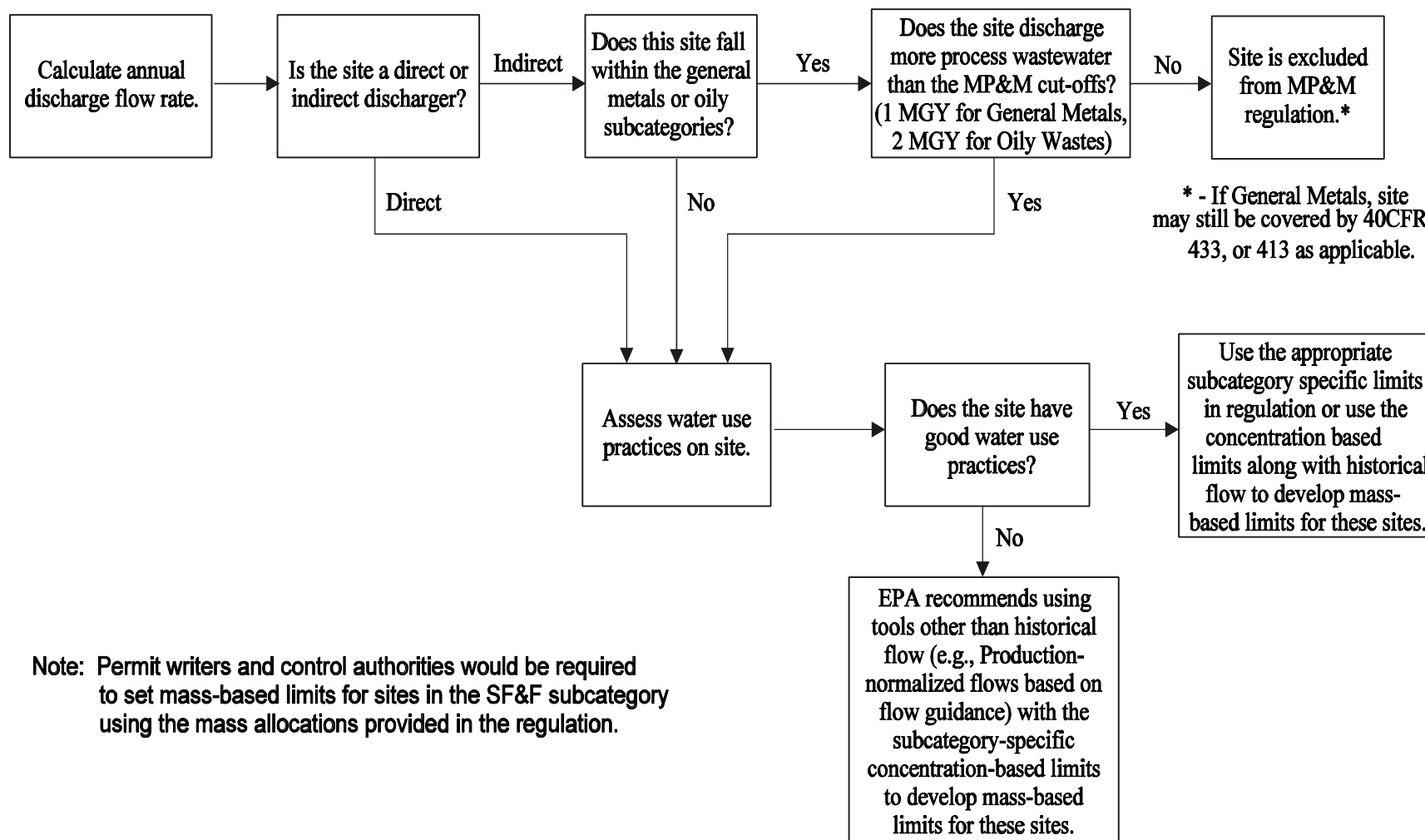


Figure 15-1. MP&M Permitting Process Flow Chart

The equation below describes the flow-weighted building block approach for calculating concentration-based daily maximum limits.

$$C_T = \sum_j \frac{F_L}{F_T} \times C_L \quad (15-1)$$

where:

C_T	=	The alternate concentration limit for the combined wastestream (mg/L);
C_L	=	The categorical effluent limitation concentration limit for a pollutant in the regulated stream (mg/L);
F_L	=	The average daily flow of stream (L/day); and
F_T	=	The total daily flow of all combined streams (L/day).

To use the building block approach (and combined wastestream formula) to arrive at a single set of technology-based effluent limits for the facility, the permit writer or control authority can use the following steps:

Step 1. Determine the concentration-based or mass-based limits for each industrial category.

Step 2. Determine the flow rates for the unit operations in each industrial category. For facilities with good pollution prevention and water conservation practices in place, flow rates can be estimated from historical flow data. For facilities without good pollution prevention and water conservation practices in place, the permit writer or control authority can estimate flows using the production normalized flows (PNFs) provided in Table 15-1 and can make a reasonable estimate of production (see Section 15.2.4).

Step 3. Multiply the concentration-based limit (mg/L) from each industrial category by the flow rate (L/day) from the industrial category to determine a daily mass (mg/day). Sum the daily mass from each category and divide by the total combined flow rate at the monitoring point.

The following is an example showing how the building block approach can be used to calculate an effluent limit for nickel when two categorical wastewaters are combined in a single treatment system.

Example 1

A household equipment manufacturer has effluent limitations for nickel under two categorical standards (MP&M and Porcelain Enameling (40 CFR Part 466)), and combines each wastestream in a single wastewater treatment system. Assuming the facility has good pollution prevention and water conservation practices in place, the maximum daily limit for nickel following treatment would be calculated as follows:

MP&M General Metals maximum daily Nickel limit: 0.5 mg/L, example flow: 75,700 L/day
(20,000 gal/day)

Part 466 maximum daily Nickel limit¹: 0.37 lbs/1 million ft² (coating), example
flow: 151,400 L/day (40,000 gal/day),
example coating throughput: 600,000 ft²/day.

Part 466 maximum daily Nickel concentration:

$$\frac{0.37 \text{ lbs/1 million ft}^2 \times 0.6 \text{ million ft}^2/\text{day} \times 1,000,000 \text{ mg/kg}}{2.2 \text{ lbs/kg} \times 151,400 \text{ L/day}}$$

Nickel concentration: 0.67 mg/L

Combined MP&M and Part 466 Nickel concentration (daily max) =

$$\left(\frac{75,700 \text{ L/day}}{75,700 \text{ L/day} \% 151,400 \text{ L/day}} \times 0.5 \text{ mg/L} \right) \% \left(\frac{151,400 \text{ L/day}}{75,700 \text{ L/day} \% 151,400 \text{ L/day}} \times 0.67 \text{ mg/L} \right)$$

Combined Nickel concentration limit (daily max) = 0.17 + 0.45 = 0.62 mg/L

15.2.2 Application of the Combined Wastestream Formula for Indirect Dischargers

When a facility has multiple categorical effluent limitations and discharges to a POTW, the control authority must apply the combined wastestream formula (40 CFR Part 403.6(e)) to calculate the pretreatment standards. The combined wastestream formula is based on three types of waste streams that can exist at an industrial facility: regulated, unregulated, and dilute. A regulated wastestream from an industrial process is regulated by a categorical pretreatment standard for a pollutant. An unregulated wastestream is not covered by a categorical pretreatment standard and is not classified as a dilute stream, or is not regulated for the pollutant in question, although it is regulated for others. A dilute stream includes sanitary wastewater, noncontact cooling water and boiler blowdown, and waste streams listed in Appendix D to 40 CFR Part 403.

According to 40 CFR Part 403, the combined wastestream formula is:

$$C_T = \frac{\sum_j \frac{C_I F_I}{F_I}}{\sum_j \frac{F_T \& F_D}{F_T}} \quad (15-2)$$

where:

C_T = The alternate concentration limit for the combined wastestream (mg/L);

¹Production-based BAT nickel limit for porcelain enameling (coating operation) is 0.37 lbs/1 million ft² (40 CFR Part 466)

C_I	=	The categorical pretreatment standard concentration limit for a pollutant in the regulated stream I (mg/L);
F_I	=	The average daily flow of stream I (L/day);
F_D	=	The average daily flow from dilute waste streams as defined in 40 CFR Part 403 (L/day); and
F_T	=	The total daily flow (L/day).

As described in 40 CFR Part 403, the methodology for developing combined wastestream formula daily maximum limits is essentially the same as the methodology for the “building block” approach used for direct dischargers (24). If a site combines wastewater regulated by multiple pretreatment standards prior to treatment or discharge to a POTW, then the control authority would combine the allowable pollutant concentrations or loadings for each category (proportioning the flow appropriately) to arrive at a single set of technology-based pretreatment standards for the facility.

Like the building block approach, the permit writer or control authority can also use the combined wastestream formula on mass-based limitations. The example below shows how to calculate a mass-based limit for zinc when multiple categorical wastewaters are combined.

Example 2

A household equipment manufacturer with good water conservation practices in place, combines wastewater from the MP&M General Metals subcategory, the Porcelain Enameling category, and the Copper Forming category at an on-site chemical precipitation and clarification wastewater treatment system. Effluent from the treatment system is combined with sanitary wastewater at the outfall to the POTW.

Industrial Category	Wastestream Type	Historical Flow (mgd)	Zn Limit (mg/L)
MP&M General Metals	Regulated	0.1	0.38
Porcelain Enameling (Steel-coating Subcategory only)	Regulated	0.075	1.33 ¹
Copper Forming	Regulated	0.4	Production Based ²
Sanitary Waste	Dilution	0.05	N/A

1. Alternate Mass/Production based limits 53.3 mg/m² for preparation and 1.68 mg/m² for coating

2. Production based limits = 0.943 mg/off-kg of copper heat treated for solution heat treatment

MP&M General Metals Subcategory

Allowable Zn Mass = 0.38 mg/L × 100,000 gal/day × 3.785 L/gal = 143,830 mg/day

Porcelain Enameling

Example average daily production: 5,570 m² of preparation
7,250 m² of coating

$$\text{Allowable Zn Mass} = (53.3 \text{ mg/m}^2 \times 5,570 \text{ m}^2/\text{day}) + (1.68 \text{ mg/m}^2 \times 7,250 \text{ m}^2/\text{day}) = 309,061 \text{ mg/day}$$

Copper Forming

Example average daily production: 30,000 off-kg of copper heat treated per day

$$\text{Allowable Zn Mass} = 0.943 \text{ mg/off-kg} \times 30,000 \text{ off-kg/day} = 28,290 \text{ mg/day}$$

Combined Wastestream Formula Zinc Discharge Limit: $143,830 + 309,061 + 28,290 = 481,181$ mg/day (1.06 lbs/day)

As with direct dischargers, in circumstances when the standards for one category regulate a different set of pollutants than the standards applicable to another category, the control authority must ensure that the stream that does not contain the regulated pollutant does not dilute the stream containing the regulated pollutant to the point where the pollutant is not analytically detectable. If this occurs, federal regulations at 40 CFR Part 403.6(e)(2) and (4) authorize the control authority to establish internal monitoring points.

15.2.3 Production-Based Limits for the Steel Forming and Finishing Subcategory

As mentioned previously, EPA is proposing production-based limits for facilities in the Steel Forming and Finishing subcategory. These facilities manufacture steel products with uniform shapes (wire, rod, bar, pipe or tube) and currently track the weight of product produced. Wastewater generating manufacturing operations in the Steel Forming and Finishing subcategory include but are not limited to acid pickling, alkaline cleaning, continuous annealing, electroplating, hot dip coating, pressure deformation, lubrication, mechanical descaling and painting. EPA developed the proposed production-based limits listed in Section 14 by following the three steps below:

Step 1. Determine the technology based concentration limits for each pollutant proposed for regulation. EPA transferred the BPT/BAT concentration-based limits from the General Metals subcategory for all pollutants proposed for regulation.

Step 2. Determine the PNF for each unit operation. EPA determined the amount of water used per ton of product produced (the production-normalized flow) for each steel forming and finishing operation performed at steel forming and finishing facilities. EPA determined the PNFs for each steel forming and finishing operation by taking the median of the PNFs reported by steel forming and finishing facilities in EPA's Iron and Steel detailed questionnaire. The following

definitions of steel forming and finishing operations indicate the wastewater flows that EPA included in each of the PNF determinations.

- C Acid pickling means the removal of scale and/or oxide from steel surfaces using acid solutions. The mass-based limitations for acid pickling operations include wastewater flow volumes from acid treatment with and without chromium, acid pickling neutralization, annealing, alkaline cleaning, electrolytic sodium sulfate descaling, and salt bath descaling.
- C Alkaline cleaning means the application of solutions containing caustic soda, soda ash, alkaline silicates, or alkaline phosphates to a metal surface primarily for removing mineral deposits, animal fats, and oils. The mass-based limitations for alkaline cleaning operations include wastewater flow volumes from alkaline cleaning for oil removal, alkaline treatment without cyanide, aqueous degreasing, annealing, and electrolytic cleaning operations.
- C Cold forming means operations conducted on unheated steel for purposes of imparting desired mechanical properties and surface qualities (density, smoothness) to the steel. The mass-based limitations for cold forming operations are based on zero wastewater discharge from welding operations.
- C Continuous Annealing means a heat treatment process in which steel is exposed to an elevated temperature in a controlled atmosphere for an extended period of time and then cooled. The mass-based limitations for continuous annealing operations include wastewater flow volumes from heat treating operations.
- C Electroplating means the application of metal coatings including, but not limited to, chromium, copper, nickel, tin, zinc, and combinations thereof, on steel products using an electro-chemical process. The mass-based limitations for electroplating operations includes wastewater flow volumes from acid pickling, annealing, alkaline cleaning, electroplating without chromium or cyanide, and electroless plating operations.
- C Hot Dip Coating means the coating of pre-cleaned steel parts by immersion in a molten metal bath. The mass-based limitations for hot dip coating operations includes wastewater flow volumes from acid pickling, annealing, alkaline cleaning, chemical conversion coating without chromium, chromate conversion coating, galvanizing, and hot dip coating operations.

- C *Lubrication* means the process of applying a substance to the surface of the steel in order to reduce friction or corrosion. The mass-based limitations for lubrication operations includes wastewater flow volumes from corrosion preventive coating operations as defined in 438.61(b).
- C *Mechanical Descaling* means the process of removing scale by mechanical or physical means from the surface of steel. The mass-based limitations for mechanical descaling operations includes wastewater flow volumes from abrasive blasting, burnishing, grinding, impact deformation, machining, and testing operations.
- C *Painting* means applying an organic coating to a steel bar, rod, wire, pipe, or tube. The mass-based limitations for painting operations includes wastewater flow volumes from spray or brush painting and immersion painting.
- C *Pressure Deformation* means applying force (other than impact force) to permanently deform or shape a steel bar, rod, wire, pipe, or tube. The mass-based limitations for pressure deformation operations includes wastewater flow volumes from forging operations and extrusion operations.

The following table lists the PNFs that EPA used in determining the production based limits for this subcategory.

Steel Forming and Finishing Manufacturing Operation	PNF (gallons/ton)
Acid Pickling	500
Alkaline Cleaning	500
Cold forming	0
Continuous Annealing	25
Electroplating	1,000
Hot Dip Coating	145
Pressure Deformation	25
Lubrication	12
Mechanical Descaling	2
Painting	65

Step 3. Multiply the concentration-based limit for each regulated pollutant by the appropriate PNF from the table above and apply the conversion factor calculated below to determine the production based limit (lbs/1,000 pounds produced).

$$Limit_{pn} = \frac{Xmg}{L} \times \frac{Ygal}{short\ ton} \times \frac{8.3454\ L \times lb}{10^6\ gal \times mg} \times \frac{short\ ton}{2 \times 1000\ lb} = 0.00000417\ XY \frac{lb}{1000\ lb} =$$

$$0.00000417\ XY \frac{kg}{kkg}$$

$$conversion\ factor = \frac{3.7854\ L}{gal} \times \frac{lb}{453.593 \times 10^3\ mg} = 8.3454 \times 10^{-6} \frac{L/gal}{mg/lb}$$

Where X (mg/L) is the Steel Forming and Finishing subcategory concentration and Y is the appropriate PNF (gallon/ton).

The production-based limits that EPA calculated for the Steel Forming and Finishing subcategory using the three steps above, are listed in Section 14. In order to develop a production-based limit for a Steel Forming and Finishing subcategory facility, the permit writer or control authority uses the Steel Forming and Finishing limits established by EPA and listed in Section 14 and carries out the following two steps:

Step 4. Determine a reasonable production rate in lbs/day for each of the steel forming and finishing manufacturing operations (see Section 15.2.6 - Estimating Reasonable Production Rates).

Step 5. For each steel forming and finishing manufacturing operation and for each pollutant proposed for regulation, multiply the production based limit (lbs of pollutant/1,000 pounds of product produced) by the production rate (lbs of product/day) to obtain the allowable pollutant discharge (lbs pollutant/day).

15.2.4 Use of Site-Specific Historical Flow Data to Calculate Flow-Based Mass Limitations

Although EPA is not proposing to require permit writers and control authorities to convert the proposed concentration-based limits to mass-based limits, EPA does provide the authority to do so in the proposed rule. In cases where the permit writer or control authority is going to develop mass-based limitations for a site with sufficient pollution prevention and water conservation practices in place, the Agency recommends that the permit writer or control authority use the site's historical process wastewater flow information. Cases may also exist where a facility that incorporates pollution prevention and water conservation practices may request that their permit

limits be mass-based. EPA believes that the use of historical flow to develop the limits is appropriate in these cases as well. The use of historical flow data that reflects pollution prevention and water conservation practices at a site reduces the opportunity for sites to dilute their flow to achieve concentration limits. This approach also encourages sites to evaluate existing and potential pollution prevention and water conservation opportunities.

Historical flow should be calculated as a reasonable estimate of the actual long-term discharge flow rate from a site for sites with sufficient P2 and water conservation practices. To develop a site-specific historical flow rate, permit writers and control authorities should review the site's pollution prevention and water conservation practices as well as long-term records of the site's flow on a monthly basis (e.g., over a 5 year period). Then, to determine the site's flow-based mass-limits, the permit writer/control authority multiplies the flow rate by the concentration limit for each pollutant.

Several documents published by the EPA's Office of Wastewater Enforcement and Compliance, Washington, DC, provide guidance for determining the appropriate process wastewater flow rate (26).

15.2.5 Use of General MP&M Industry Flow Data to Develop Flow-Based Mass Limitations

When sites do not have pollution prevention and water conservation practices in place, the Agency recommends that the permit writer use methods other than historical flow and production data to calculate mass-based limitations. One of these methods uses an estimate of the flow reduction, as a percentage of the current flow, if the site implements pollution prevention and water conservation practices. The other method uses unit-operation-specific PNFs to calculate a maximum combined MP&M flow rate for the entire site. The PNF is the amount of wastewater generated per unit of product manufactured, rebuilt, or repaired and is measured as either gallons per square foot of metal surface area or gallons per ton of metal processed. If the facility's PNF in subsequent operational years remains at or below the PNF that the permit writer or control authority determined to reflect good water use practices, then the facility is likely not diluting to achieve the new MP&M limits.

In order to determine the flow-based mass limits, the permit writer/control authority would multiply a PNF, representative of good water use practices, times an appropriate measure of production (i.e., square feet processed) to get a flow rate. Then, to determine the site's flow-based mass-limits, the permit writer/control authority multiplies the flow rate by the concentration limit for each pollutant.

The data and information contained throughout this section should assist permit writers and control authorities in establishing the flow reductions achieved by pollution prevention practices and in establishing PNFs for MP&M unit operations that reflect good water use practices.

Pollution Prevention and Water Conservation Practices

EPA observed a number of pollution prevention and water conservation practices during site visits and sampling episodes and MP&M surveys provided additional information on these practices. Some of the common pollution prevention and water conservation methods for surface treatment include drag-out tanks, countercurrent rinsing, manual and automatic rinsewater shut-off, timed rinses, flow restrictors, conductivity meters, and in-process ion exchange and water recycle. The table below shows the estimated number of MP&M facilities currently using one or more of these techniques to limit flow.

Estimated Number of MP&M Facilities Using Various Pollution Prevention and Water Conservation Practices to Limit Flow

Flow Control Practice	Number of MP&M Facilities ¹
Two-stage countercurrent rinsing	1,429
Three-stage countercurrent rinsing	745
Manual rinsewater shut-off	2,464
Automatic rinsewater shut-off	426
Timed rinses	777
Flow restrictors	1,581
Conductivity meters	317
Ion exchange and water recycle	347

¹Estimates of the number of MP&M facilities using the listed flow control practices are based on the 1996 MP&M Detailed Surveys, which represents 4,300 sites. The 1989 survey did not collect this information.

To assist permit writers in estimating if flows from an MP&M facility are excessive or not when the facility does not use pollution prevention and water conservation practices, EPA analyzed flow and production data for various rinse schemes. First, EPA determined the most commonly used rinsing operations from the MP&M detailed surveys. Next, using the flow and production data from each site, EPA calculated PNFs for each rinsing operation. The table below shows the seven most common rinse types reported in the MP&M detailed survey, along with the calculated median PNFs for each rinse type.

Seven Most Common Rinse Types Reported by MP&M Facilities and Median PNFs

Rinse Type	Median PNF (gal/ft ²)	Number of Observations
Two-stage overflow	5.0	2,332
One-stage overflow	2.0	12,867
Spray rinse	1.43	2,563
Drag-out plus one-stage overflow	1.25	1,179
Two-stage countercurrent	1.02	5,761
Three-stage countercurrent	0.44	1,045
Drag-out	0.16	2,156

Source: MP&M 1996 Detailed Surveys.

The data shown in the table above indicate that the most commonly used rinse types are one-stage overflow and two-stage countercurrent. As discussed in Section 9.0, EPA's proposed technologies include two-stage countercurrent rinses as part of the water conservation practices.

Using the median PNFs, EPA calculated the reduction in flow (percent) expected if a facility changed from poor water use rinse types with high PNFs to a two-stage countercurrent rinse type. Applying the percent flow reduction, the permit writer or control authority can estimate the flow rate from the rinsing operation if the facility changed to a two-stage countercurrent rinse (median PNF is 1.02). The table below shows the expected flow reductions for changing from various rinse types to a two-stage countercurrent rinse type.

Flow Reduction Expected After Changing From Various Rinse Types to Two-Stage Countercurrent

Rinse Type	Expected Flow Reduction
Two-stage overflow	79.5 %
One-stage overflow	48.8 %
Spray rinse	28.4 %
Drag-out plus one-stage overflow	18.1 %

Source: MP&M 1996 Detailed Surveys.

Unit Operation PNFs

Permit writers or control authorities can use the PNFs provided in this section as an indicator of water use practices. Table 15-1 presents descriptive statistics for PNFs obtained from the MP&M surveys. For most unit operations, EPA based the PNFs on surface area as the production-normalizing parameter (Table 15-1(a)). For five operations (abrasive jet machining,

electrical discharge machining, grinding, machining, and plasma arc cutting), the mass of metal removed is the production-normalizing parameter (Table 15-1(b)).

Table 15-1 presents the following information for each of the MP&M unit operations:

- C Total occurrences in the MP&M survey data (i.e., the number of times the unit operation was reported, regardless of whether flow and production data were available to calculate PNFs);
- C Number of source occurrences for which flow and production data were available to calculate PNFs;
- C Minimum PNF reported;
- C Maximum PNF reported;
- C Median PNF reported;
- C Mean PNF reported;
- C Upper and lower quartile PNF reported; and
- C Tenth and ninetieth percentile PNF reported.

The sites that responded to the MP&M surveys have implemented pollution prevention and water conservation practices to varying degrees. Some sites exhibited poor water use practices, while other sites effectively implemented one or more pollution prevention or water conservation practices. As a result, the PNFs in Table 15-1 vary widely, by several orders of magnitude or more in some cases. These results are not surprising, given the drastic effects of pollution prevention and water conservation practices on reducing flow. For example, implementing one practice, such as converting a two-stage overflow rinse to a two-stage countercurrent rinse, can reduce water use by almost 80 percent. Differences in manufactured parts or processing requirements also affect PNFs.

15.2.6 Estimating Reasonable Production Rates

As discussed above, the permit writers or control authorities can use PNFs to calculate flow rates for developing mass-based limits. The PNF can be multiplied by a reasonable production rate (in square feet or pounds of metal removed per day, pounds of product produced per day, etc.) through each unit operation to estimate a flow rate for that unit operation. In the proposed rule, particularly in reference to the Steel Forming and Finishing production-based limits, the Agency is considering four alternatives (A through D) for determining reasonable production rates. Each alternative requires only unit operations that generate or

discharge process wastewater be included in the calculation of production rates. Each of these alternatives is discussed below. In the proposal, EPA is soliciting comment on each alternative for determining reasonable production rates.

Alternative A: This alternative retains the essential requirements of the rule that EPA currently regulates Steel Forming and Finishing facilities under (40 CFR Part 420.04). The alternative requires the permit writer or control authority to use the following protocols:

- C For similar, multiple production lines with process waters treated in the same wastewater treatment system, production can be determined from the combined production of the similar production lines during the same time period.
- C For process wastewater treatment systems where wastewater from two or more different production lines are commingled in the same wastewater treatment system, production shall be determined separately for each production line (or combination of similar production lines) during the same time period.

This method also avoids calculating unrealistically high production estimates by only considering production from all production units that could occur simultaneously.

Alternative B: The Agency is considering including in the rule a requirement for the permit writer/control authority to establish multi-tiered limits and pretreatment standards. Permit writers and control authorities currently use their best professional judgment for establishing multi-tiered permits. The Agency has issued guidance for use in considering multi-tiered permits (see Chapter 5 of the “U.S. EPA NPDES Permit Writers’ Manual,” (EPA-833-8-96-003, December 1996) and Chapter 7 of the “Industrial User Permitting Guidance Manual,” (EPA 833/R-89-001, September 29, 1989)).

In situations where a single set of effluent limitations or standards are not appropriate for the permit’s (or control mechanism’s) entire period, a tiered permit/control mechanism may be established. One set of limits would apply for periods of average production along with other sets which take effect when there are significant changes in the average production rate. The guidance notes that a 10 to 15 percent deviation above or below the long-term average production rate is within the range of normal variability. Predictable changes in the long-term production higher than this range would warrant consideration of a tiered or multi-tiered permit/control mechanism. Based on EPA’s limited data, the facilities in the Steel Forming and Finishing subcategory may have a variable production rate where the permit/control mechanism modification process is not fast enough to respond to the need for higher or lower equivalent limits.

Alternative C: To provide a basis for deriving a permit/control mechanism production rate that is consistent with the term *reasonable measure of actual production* and that

can be applied consistently for facilities in the Steel Forming and Finishing subcategory, EPA is also considering including a definition of “production” specific to this subcategory. The modified definition for use in developing the permit/control mechanism production basis would be the average daily operating rate for the year with the highest annual production over the past five years, taking into account the annual hours of operation of the production unit and the typical operating schedule of the production unit, as illustrated by the following example:

Highest annual production from previous five years	3,570,000	tons
Operating hours	8,400	hours
Hourly operating rate	425	tons/hour
Average daily operating rate (24 hour day)	10,200	tons/day

The above example is for a unit process that is operated typically 24 hours per day with short-term outages for maintenance on a weekly or monthly basis. For facilities in the Steel Forming and Finishing subcategory that are operated typically less than 24 hours per day, the average daily operating rate must be determined based on the typical operating schedule (e.g., 8 hours per day for a facility operated one 8-hour turn (or shift) per day; 16 hours per day for a facility operated for two 8-hour turns per day). For example:

Highest annual production from previous five years	980,000	tons
Operating hours	4,160	hours
Hourly operating rate	235.6	tons/hour
Average daily operating rate (16 hour day)	3,769	tons/day

In this example, EPA recognizes that the approach could cause problems for a facility that was operated 16 hours/day at the time the permit was issued and then wished to change to 24 hours/day based on unforeseen changes in market conditions. To address this issue, the approach could be combined with the tiered permit approach discussed above.

For multiple similar process units discharging to the same wastewater treatment system with one compliance point (e.g., two electroplating lines operated with one treatment system for process waters), the year with the highest annual production over the previous five years under Alternative C would be determined on the basis of the sum of annual production for both electroplating lines. Then, based on this year’s average daily operating rate, the daily production rates would be calculated as above independently for each electroplating line using total annual production and annual operating hours for each line. The daily production values would be summed to calculate the average daily operating rate for the combination of the two lines. For example, consider the following production data:

Year	Electroplating Line A (tons)	Electroplating Line B (tons)	Total (tons)
1995	<u>1,859,000</u>	1,305,000	3,155,000
1996	1,675,000	<u>1,425,000</u>	3,100,000
1997	1,760,000	1,406,000	3,166,000
1998	1,580,000	1,328,000	2,908,000
1999	1,825,000	1,380,000	<u>3,205,000</u>

Annual maximum production rates for each electroplating line and the combination of the two lines are underlined. In this example, 1999 was the maximum production year for the combination of the electroplating lines and the data from each line that year would be used to calculate the average daily operating rates. Had the 1995 data from Electroplating Line A and the 1996 data from Electroplating Line B been used in combination (3,275,000 tons), an unrealistic measure of actual production might have resulted if the two electroplating lines could not produce at these high levels concurrently.

In contrast to the previous example, for multiple process units that are not similar, but have process wastewater commingled prior to treatment in one central wastewater treatment system with one compliance point, the year with the highest production over the previous five years would be determined separately for each production unit (or combination of similar and different production units) with the highest annual production. For example, consider a situation where process wastewater for an electroplating line, a pressure deformation operation, and an acid pickling operation are discharged through one compliance point. Consider the following example:

Year	Electroplating (tons)	Pressure Deformation (tons)	Acid Pickling (tons)
1995	575,000	650,000	900,000
1996	650,000	700,000	1,000,000
1997	675,000	<u>850,000</u>	950,000
1998	<u>750,000</u>	825,000	<u>1,125,000</u>
1999	700,000	600,000	900,000

In this example, 1998 production data for the electroplating line, 1997 data from the pressure deformation operation, and 1998 data for the acid pickling operation would be used to develop the effluent limitations or pretreatment standards used in the permit/control mechanism.

Alternative D: The Agency is considering establishing production-based maximum monthly average effluent limitations and standards in combination with daily-maximum concentration-based effluent limitations and standards. Under this alternative, the maximum monthly average NPDES permit and pretreatment control mechanism mass basis requirements would be determined using Steel Forming and Finishing production-based standards listed in Section 14 in combination with a reasonable measure of actual production, such as Alternative C above. However, the daily-maximum requirements would be in the form of effluent concentrations in lieu of the daily-maximum production-based mass effluent limitations guidelines and standards. These daily maximum concentrations set out as effluent limitations guidelines and standards would be based on the long-term averages and variability factors derived from EPA sampling conducted post-proposal at steel forming and finishing facilities representative of BAT.

The Agency believes this approach would effectively address the potential issue cited above regarding short-term peaks in production under most circumstances. There would be no additional burden on the industry and permitting or control authorities for applying for and writing NPDES permits or pretreatment control mechanisms. Permitting and control authorities may need to revise their automated compliance tracking systems to account for both mass and concentration limitations at the same outfall, which is a common feature in many NPDES permits and pretreatment control mechanisms issued prior to this proposal.

When using the appropriate production data and PNFs for conversion of concentration-based limits to mass-based limits, the permit writer or control authority can select an appropriate PNF from Table 15-1 for each unit operation on site. EPA recognizes that in certain subcategories, production by unit operation may not be available (e.g., surface area electroplated for parts that are not standard shapes like door knobs). The Agency also recognizes that different part configurations and processing requirements may result in differing water use requirements, even for multiple occurrences of the same operation at a site. For example, a site manufacturing aerospace components may require a higher PNF for rinsing internal electronic components after electroplating than for rinsing outer casings after electroplating. Because of this diversity, while encouraging the use of lower PNFs, the Agency has provided a distribution of PNFs for each unit operation so that permit writers and control authorities can use a site-appropriate PNF.

While variations in water flow per unit of production result from variations in the part configurations and processing requirements, on-site observations indicate that they are more frequently the result of imprecise or inadequate control of water use. The permitting authority should be aware of additional factors influencing PNFs, and the impact of these factors on the appropriate PNF for an operation at a site. Sections 15.3 through 15.5 provide additional guidance on determining the appropriate PNFs for the major MP&M wastewater-generating unit operations.

15.2.7 Monitoring Flexibility

EPA is proposing several flexible monitoring alternatives to reduce burden on MP&M facilities and permit writers/control authorities. This section discusses the monitoring waiver for pollutants that are not present, monitoring for organic pollutants, and monitoring for cyanide. The proposed rule also discusses several other possible monitoring alternatives that were not proposed but are being considered for the final rule (i.e., site-specific correlation for an organic pollutant indicator parameter, pretreatment sulfide monitoring waiver, and a pollution prevention alternative).

Monitoring Waiver for Pollutants Not Present

In an effort to reduce monitoring burden on facilities, EPA is proposing to allow MP&M indirect discharge facilities to apply for a waiver that would allow them to reduce their monitoring burden. In order for a facility to receive a monitoring waiver, the facility would need to certify in writing to the control authority (e.g., POTW) that the facility does not use, nor generate in any way, a pollutant (or pollutants) at its site and that the pollutant (or pollutants) is present only at background levels from intake water and without any increase in the pollutant due to activities of the discharger. The facility would need to base this certification on sampling data or other technical factors. For example, if a site does not use or generate cyanide on-site they could submit a written certification and would not have to monitor for cyanide to demonstrate compliance with the MP&M limits.

The certification would not be a waiver from the pollutant numerical limit in the control mechanism (i.e., permit). It would only be a waiver from the monitoring requirements. EPA is proposing that the certification statement be submitted at the same time indirect discharging MP&M facilities submit “periodic reports on continued compliance” as directed by the General Pretreatment Standards (40 CFR 403.12(e)). Indirect dischargers submit such reports twice per year (typically June and December). In addition, the certification would need to be signed by the same individual that is authorized to sign the periodic reports as described in the General Pretreatment Standards 403.12(l). In addition, EPA would still require the industrial user to monitor for the specified pollutants as part of the Baseline Monitoring Report (403.12(b)) and the 90-day Compliance Report (403.12(d)). EPA believes control authorities can use the sampling data generated from the Baseline Monitoring Report and the 90-day Compliance Report in conjunction with technical information on the raw materials and chemical processes used at the facility to determine whether there is sufficient reason to allow the monitoring waiver for any of the MP&M limited pollutants. This monitoring waiver would be similar to the waiver in the Proposed “Streamlining the General Pretreatment Regulations for Existing and New Sources of Pollution,” 64 FR 39564; July 22, 1999 (commonly referred to as “Pretreatment Streamlining”) and the waiver that was finalized for direct discharges in the “Amendments to Streamline the NPDES Program Regulations: Round Two (65 FR 30886; 5/15/00).

Monitoring Alternatives for Organic Pollutants

To reduce the burden associated with monitoring for organic pollutants, EPA has decided to propose three alternatives to allow for maximum flexibility while ensuring reductions in the amount of organic pollutants discharged from MP&M facilities. In most subcategories, EPA is proposing to require MP&M facilities within the scope of the rule to either: (1) meet a numerical limit for the total sum of a list of specific organic pollutants called “Total Organics parameter” or “TOP” (similar to the TTO parameter used in the Metal Finishing effluent guidelines); (2) meet a numerical limit for total organic carbon as an indicator parameter; or (3) develop and certify the implementation of an organics management plan. Each of these alternatives is discussed below.

For the first alternative, EPA is proposing an approach similar to the one used in the Metal Finishing Effluent Guidelines (40 CFR Part 433). EPA developed the TOP list, using the list of organic priority pollutants and other nonconventional organic pollutants that met EPA's "pollutant of concern" criteria for this rule. Of the non-conventional organic chemicals on the MP&M pollutant of concern list, EPA included only those that were removed in appreciable quantities by the selected technology option (based on toxic weighted pound-equivalents) in two or more subcategories. EPA then derived a numerical limit for TOP based on the contribution of each of the organic pollutants described in Section 7 using the data collected during sampling and determined its limitation using the statistical methodology outlined in Section 10. Facilities will only have to monitor for those TOP chemicals that are reasonably present. (See discussion on monitoring waiver for pollutants not present).

For compliance purposes, pollutants that have been given a waiver (because they are not reasonably present) will be counted as zero in the TOP limit. For remaining pollutants, the reported value, when above the detection limit, shall be used in the TOP calculation. When a pollutant is reported as a “non-detect” (i.e., not found above the nominal quantitation limit), the nominal quantitation value shall be used in the TOP calculation. (Pollutant parameters not detected in any samples collected during the MP&M sampling program are shown in Table 7-2.)

The second alternative proposed by EPA to lessen the monitoring burden is the use of an indicator parameter (i.e., total organic carbon) to measure the presence of organic pollutants in MP&M process wastewater. EPA chose TOC as an indicator parameter because of its ability to measure all types of organic pollutants. EPA found TOC to be the best general indicator parameter for measuring the sum of organic compounds in a wastestream. (See DCN 16028 in Section 6.3 of the Public Record).

Finally, EPA is proposing a third alternative to reduce monitoring burden – the use of an organic pollutant management plan. The organic pollutant management plan would need to specify, to the satisfaction of the permitting authority or control authority, the toxic and non-conventional organic constituents used at the facility (not only those on the TOP list); the disposal method used; the procedures in place for ensuring that organic pollutants do not routinely spill or leak into the wastewater or that minimize the amount of organic pollutants used

in the process; the procedures in place to manage the oxidation reduction potential (ORP) during cyanide destruction to control the formation of chlorinated organic byproducts; and the procedures to prevent the over dosage of dithiocarbamates when treating chelated wastewater. Facilities choosing to develop an organic pollutant management plan would need to certify that the procedures described in the plan are being implemented at the facility.

Monitoring Alternatives for Cyanide

For the General Metals, Metal Finishing Job Shop, Printed Wiring Board, and Steel Forming and Finishing subcategories, EPA is proposing to set a total cyanide limit. The point of compliance would be based on monitoring for total cyanide directly after cyanide treatment, before combining the cyanide treated effluent with other wastestreams. EPA is also proposing an alternative where a facility may take samples of final effluent, in order to meet the total cyanide limit, if the permitting/control authority adjusts the limit based on the dilution ratio of the cyanide wastestream flow to the effluent flow.

In addition, EPA has selected alkaline chlorination using sodium hypochlorite as the best available economically achievable technology for treating cyanide bearing wastewater from MP&M facilities. Not all cyanide however is amenable to alkaline chlorination due to “unavoidable” complexing with other compounds at the process source of the cyanide-bearing wastestreams. EPA believes that for some facilities it may be more accurate to monitor for the portion of cyanide in their wastewater that is amenable to alkaline chlorination than to measure total cyanide which may include cyanide complexes that this technology is not likely to treat. Therefore, EPA is also proposing an alternative “amenable cyanide” limit for each of these subcategories which a facility may use directly after cyanide treatment (e.g., before combining the cyanide treated effluent with other wastestreams).

The Agency proposes to allow the use of the amenable cyanide limit upon the agreement of the facility and its permit writer or control authority (e.g., POTW). However, when segregated cyanide treatment is in place as a preliminary step prior to commingling wastewater for chemical precipitation, EPA is proposing to allow the amenable cyanide alternative limit to be measured at the end-of-pipe (i.e., final effluent) if the control authority adjusts the permit limits based on the dilution ratio of the cyanide wastestream flow to the effluent flow.

If facilities are not using cyanide destruction treatment on cyanide-bearing wastestreams prior to commingling with metal-bearing streams, additional complexing can occur. This additional complexing would render the cyanide “non-amenable” when it would otherwise be amenable to alkaline chlorination. EPA considers such complexing to be “avoidable” and would not allow the use of end-of-pipe monitoring for amenable cyanide when in-process cyanide destruction is not performed.

15.3 Flow Guidance for Surface Treatment Rinsing Operations

Surface treatment rinses include those following acid and alkaline treatment, anodizing, electroplating, electroless plating, and chemical conversion coating. Rinsing dilutes and removes the chemical film of drag-out remaining on parts and racks after processing in a chemical bath. This subsection presents guidance for selecting the appropriate flow rate from surface treatment rinsing operations for sites that do not have pollution prevention and water conservation practices in place. EPA based the guidance on MP&M survey data, site visits, and technical literature on various factors that impact rinse-water requirements, such as drag-out rates and the required cleanliness or quality of rinse water.

Section 15.3.1 provides background information to identify pollution prevention and water conservation practices applicable to surface treatment rinsing operations and evaluation criteria to assess if a particular site has properly implemented these practices. Section 15.3.2 shows the influences on flow rates from surface treatment rinsing operations. Section 15.3.3 presents guidance for PNF selection.

15.3.1 Identification of Sites With Pollution Prevention and Water Conservation Practices

As discussed in Section 15.1, the Agency recommends that permit writers or control authorities use historical flow data to calculate mass-based limitations, when needed, for sites that have implemented pollution prevention and water conservation practices. This subsection provides background information and guidance that the permit writer or control authority can use to determine if a site has implemented pollution prevention and water conservation practices. If the site has implemented these types of practices, the permit writer can multiply the site's historical process wastewater discharge flow rate by the subcategory-specific concentration-based limitations to calculate mass-based limitations. This eliminates having to identify alternate methods to develop mass-based limitations, including tracking production rates through unit operations.

Many MP&M sites use some form of water conservation. Some sites implement numerous water conservation methods and technologies in combination that result in very low rinsewater discharge rates and in some cases eliminate the discharge of rinse water from individual processes. Water conservation is applicable to every flowing rinse; however, process-related factors and site-specific conditions may restrict the use of certain methods. This subsection identifies pollution prevention and water conservation practices and technologies applicable to surface finishing rinses, presents example configurations of these practices and technologies at MP&M sites, and provides guidance on how to evaluate a site's water use practices.

Pollution Prevention and Water Conservation Practices for Surface Treatment

The Agency identified four categories of pollution prevention and water conservation practices and technologies that can be applied to reduce rinse-water use: drag-out reduction and/or drag-out recovery methods; improved rinse tank design and innovative rinsing configurations; rinse-water use control devices; and, metal recovery and rinse-water reuse technologies. In addition to conserving water use, some of these methods (especially those that affect drag-out and recover chemicals) also conserve raw materials and reduce treatment reagent requirements and sludge production. Within each of these categories are several specific practices and technologies. Table 15-2 presents examples of these practices and technologies, as well as their applicability to the MP&M unit operations. Table 15-3 provides definitions of these practices.

Drag-Out Reduction and Drag-Out Recovery. The quantity of water needed for good rinsing for a given system is proportional to the quantity of drag-out from a process bath. Sites can implement various methods that minimize the rate of drag-out (measured as gallons per square foot of part surface area) and/or they can implement direct drag-out recovery. The drag-out rate for an individual process operation (e.g., cleaning or plating) depends on numerous factors, including process type, shape of parts processed, production equipment, and processing procedures, which include human factors. Of these factors, the shape of the parts and the type of device used to move the parts (e.g., racks, baskets, barrels) usually have the greatest influence on drag-out rates. The following tables present drag-out rate estimates for various shaped parts.

Estimates of Drag-Out Generation Presented in Literature Average Drag-Out Losses - from Soderberg's Work

Nature of Work Drainage	Drag-Out Rate (gal/1,000 ft ²)
VERTICAL	
Well drained	0.4
Poorly drained	2.0
Very poorly drained	4.0
HORIZONTAL	
Well drained	0.8
Very poorly drained	10.0
CUP SHAPES	
Well drained	8.0
Very poorly drained	24.0

Source: Reference 1.

Average Drag-Out Losses - from Hogaboom's Work

Electroplating Solution Type	Drag-Out Rate (gal/1,000 ft ²)	
	Flat Surfaces	Contoured Surfaces
Brass	0.95	3.3
Cadmium	1.00	3.1
Chromium (33 oz/gal)	1.18	3.0
Chromium (53 oz/gal) ^a	4.53	11.9
Copper cyanide	0.91	3.2
Watts nickel	1.00	3.8
Silver	1.20	3.2
Stannate tin	0.83	1.6
Acid zinc	1.30	3.5
Cyanide zinc	1.20	3.8

Source: Reference 1.

^aIncreased viscosity, caused by an increase in concentration, can increase the drag-out volume approximately three times with less than double the concentration increase.

Soderberg's data indicate that the shape of the part has a significant influence on drag-out rate. Cup-shaped parts, including intricately designed parts with internal surfaces, can generate five or more times the drag-out than flat surfaced parts with the same surface area. Hogaboom's data show a similar trend for flat versus contoured surfaces. These data also show that the type and concentration of the electroplating solution influence the drag-out rate. For example, some solutions, such as stannate tin, drain effectively, while others, such as concentrated chromium electroplating solutions (53 oz/gal) drain poorly. As to the type of device used to move parts, barrels (used to hold fasteners or other small parts that cannot be practically held by racks) generate more drag-out than racks, because of the surface area of the barrel and its tendency to hold the solution.

The drag-out rate for a given process and part is influenced by several factors other than shape, some of which are interrelated. Table 15-4 lists these and other key factors and describes their impact on drag-out rates. Also listed are examples of water conservation practices that reduce the generation of drag-out, and the major restrictions that are associated with these practices. The following table shows the effect of altering the withdrawal rate and drain time.

Effect of Withdrawal Rate and Drain Time on Drag-out Rate^a

Micro-Etch Results	Withdrawal Rate (ft/min)	Time of Withdrawal (seconds)	Drain Time (seconds)	Total Time (seconds)	Drag-out (gal/1,000 ft²)
Baseline	100	1.7	3.4	5.1	3.13
Slower rate of withdrawal	11	14.9	2.5	17.4	1.73
Intermediate withdrawal rate and longer drain time	40	4.3	12.1	16.4	1.83

Electroless Copper Results	Withdrawal Rate (ft/min)	Time of Withdrawal (seconds)	Drain Time (seconds)	Total Time (seconds)	Drag-out (gal/1,000 ft²)
Baseline	94	1.8	5.2	7.0	1.55
Slower Rate of Withdrawal	12	13.9	3.2	17	0.78
Intermediate Withdrawal Rate and Longer Drain Time	40	4.3	11.9	16.3	0.75

Source: Reference 1.

^aThe effects of changing the withdrawal rate and drain time were measured at a printed circuit board manufacturing site.

The following is a list of drag-out reduction practices that can be implemented on electroplating or surface finishing lines:

- C Lower process solution viscosity and/or surface tension by lowering chemical concentration, increasing bath temperature, or using wetting agents;
- C Reduce drag-out volume by modifying rack/barrel design and perform rack maintenance to avoid solution trapping;
- C Position parts on racks in a manner that avoids trapping solution;
- C Reduce speed of rack/barrel withdraw from process solution an/or increase dwell time over process tank;
- C Rotate barrels over the process tank to improve drainage;
- C Use spray/fog rinsing over the process tank (limited applicability);

- C Use drip boards and return process solution to the process tank;
- C Use drag-out tanks, where applicable, and return solution to the process tank; and
- C Work with customers to ensure that part design maximizes drainage;

EPA believes that facilities must implement three or more drag-out reduction practices or use at least one drag-out recovery technology to have good water use practices.

Improved Rinse Tank Design and Innovative Configurations. Rinse tank design and rinsing configuration greatly influence water usage. The key objectives for optimal rinse tank design are to quickly remove drag-out from the part and completely disperse the drag-out throughout the rinse tank. Achieving these objectives reduces the time necessary for rinsing and minimizes the concentration of contaminants on the part when it leaves the rinse tank. Examples of good design include locating water inlet and discharge points of the tank at opposite positions in the tank to avoid short-circuiting, and using air agitation for better mixing (2).

Various rinsing configurations are used in the MP&M industry. Having single-rinse tanks following each process tank is the most inefficient use of rinse water. Multiple-rinse tanks connected in series (i.e., countercurrent cascade rinse) reduces the water needs of a given rinsing operation by one or more orders of magnitude. Spray rinsing can also reduce water use requirements, but the achievable percent reduction is usually less than for countercurrent cascade rinses. Other configurations that reduce water use include cascade, reactive, and dual purpose rinses.

Rinsewater Use Control. Regardless of the type of rinsing configuration they use, facilities can reduce their water use by coordinating water use and water use requirements. Matching water use to water use requirements can optimize the quantity of rinse water used for a given work load and tank arrangement (2). Not controlling water use negates the benefits of using multiple rinse tanks or other water conservation practices and increases water usage.

EPA believes that facilities should implement at least one effective method of water use control on all electroplating or surface finishing lines. Effective water use controls include, but are not limited to:

- C Use of softened or deionized water for rinsing;
- C Flow restrictors (flow restrictors as a stand-alone method of rinse water control are only effective with plating lines that have constant production rates, such as automatic plating machines. For other operations, there must also be a mechanism or procedure for stopping water flow during idle periods.);

- C Conductivity controls;
- C Timer rinse controls; and
- C Production-activated controls (e.g., spray systems activated when a rack or barrel enters/exits a rinse station).

Metal Recovery and Rinsewater Reuse Technologies. MP&M sites use various technologies to recover metals drag-out and rinses and reuse the rinsewater. The technologies most commonly used to do this are evaporation, ion exchange, electrolytic recovery (also referred to as electrowining), reverse osmosis, and electrodialysis (see Table 15-3 for definitions). The following table presents examples of metal recovery technologies and the drag-out/rinses to which they are primarily applied.

Examples of Metal Recovery Methods

Chemistry or Process with Which Rinse is Associated	Recovery Technology
Brass electroplating	Electrolytic recovery, evaporation
Cadmium (cyanide) electroplating	Electrodialysis, electrolytic recovery, evaporation, ion exchange, reverse osmosis
Cadmium (noncyanide) electroplating	Electrodialysis, electrolytic recovery, evaporation, ion exchange, reverse osmosis
Chromate conversion coating of aluminum	Evaporation
Chromium (hard) anodizing	Evaporation, mist eliminator
Chromium electroplating - decorative (Cr+6)	Evaporation
Chromium electroplating - decorative (Cr+3)	Evaporation
Copper (cyanide and sulfate) electroplating	Electrolytic recovery, evaporation, ion exchange, reverse osmosis
Gold electroplating	Electrolytic recovery, ion exchange
Lead-tin electroplating	Evaporation, ion exchange
Nickel electroplating	Electrodialysis, electrolytic recovery, evaporation, ion exchange, reverse osmosis
Nickel electroless plating	Evaporation, ion exchange
Nickel sealant	Reverse osmosis
Silver electroplating	Electrolytic recovery, evaporation, ion exchange
Zinc (cyanide) electroplating	Electrolytic recovery, evaporation, reverse osmosis
Zinc (non-cyanide) electroplating	Electrolytic recovery, evaporation, ion exchange, reverse osmosis

Chemistry or Process with Which Rinse is Associated	Recovery Technology
Zincate	Evaporation

Source: Reference 2.

Summary of Water Conservation Methods. Figures 15-2(a) through (f) present six examples of rinsing configurations with increasingly good levels of water use practices. Each of these rinse systems is described below. These configurations can be operated to provide adequate rinsing and are common at MP&M sites. However, the quantity of water needed to meet the same rinsing criteria may vary by as much as two orders of magnitude from the lowest level to the best level of water use. The proposed MP&M effluent limitations guidelines and standards are based on flow control and countercurrent cascade rinses for all flowing rinses.

Figure 15-2a is an example of inefficient water use. This configuration uses a single-rinse tank with either continuous water flow or manual use control. To coordinate rinsewater needs and use, the operator must manually turn on the water valve to give the correct flow rate and then turn it off when the flow is no longer needed. The flow-rate setting will usually vary by operator and the water valve may be left open during idle production periods. The single rinse tank configuration uses rinsewater at a very high rate, even if water use is coordinated with the introduction of drag-out. In the example shown, with a 1-gallon-per-hour (gph) drag-out rate, the rinsewater requirement is 30 gallons per minute, based on rinsing of Watts nickel plating solution and a rinsing criterion of 50 mg/L nickel. If water use and drag-out introduction are not coordinated, an even higher rinsewater use rate would be needed to meet a given rinse criterion.

Figure 15-2b shows a rinsing configuration where simple rinsewater reduction methods have been implemented. The water use is still inefficient because a single rinse tank is used versus multiple rinse tanks. However, with this configuration, the drag-out rate is reduced by controlling the withdrawal rate of the part and by holding the part over the process tank to permit the drag-out to drip into the tank. The rinsewater flow rate is controlled at a constant flow by a flow restrictor. The flow restrictor is usually sized to provide adequate rinsing at all times, and is more acceptable for constant production rates, such as those often found with automated plating machines. However, this configuration is inefficient when the work is intermittent because the rinsewater flow rate must be set high enough to provide adequate rinsing during peak production periods. In addition, a large quantity of rinsewater is wasted during low or idle production periods, unless the water flow is manually stopped.

Figure 15-2c shows a rinsing configuration using multiple rinse tanks, which provides a moderately efficient use of water. This configuration is referred to as parallel rinsing, where each of the two rinse tanks are fed with fresh water and they each discharge to treatment. This arrangement can reduce water use to less than 50 percent of that used in Figure 15-2a.

Figure 15-2d shows a more efficient rinsing configuration. This configuration is similar to that shown in Figure 15-2c, except that wastewater from the second rinse tank flows back into the first rinse tank to provide more efficient rinsing with less water use. Wastewater from the first rinse tank is then discharged to treatment. In this configuration, known as countercurrent cascade rinsing, the rinsewater flows in a direction opposite to the part flow. This arrangement can reduce water use by more than 90 percent over the rinse configuration in Figure 15-2a.

Figure 15-2e shows a very efficient rinsing configuration. There are three key elements to this rinse system: drag-out reduction/recovery; countercurrent cascade rinsing; and water-use control. This configuration reduces/recovers drag-out by controlling the withdrawal rate and dwell time and by installing a drag-out recovery tank. This tank can reduce the drag-out entering the countercurrent cascade rinses by up to 90 percent, depending on the surface evaporation rate of the process tank. A conductivity controller controls the feed to the countercurrent cascade rinses. This type of device coordinates water use with drag-out introduction and reduces the influence of human error found with manually controlled rinses. An alternative device is a timer rinse control, which is as effective as a conductivity controller when there is no variability in drag-out volume between rinsing events.

Figure 15-2f shows a rinse system that uses an ion exchange/electrolytic recovery unit as a chemical recovery and water recycling technology. This rinsing configuration can reduce water use by more than 99 percent compared to the rinse configuration in Figure 15-2a, since wastewater is discharged only from the regeneration cycle of the ion-exchange unit.

Evaluating Rinse Water Use at a Site. To identify sites with pollution prevention and water conservation practices in place for rinsing operations, a permit writer or control authority should determine if a facility has implemented three or more of the elements of good rinse system design listed below on all electroplating or surface finishing lines:

- C Select the minimum size tank in which the parts can be rinsed and use the same size for the entire plating line, where practical;
- C Locate the water inlet and discharge points of the tank at opposite positions in the tank to avoid short-circuiting or use a flow distributor to feed the rinse water evenly;
- C Use air agitation, mechanical mixing, or other means of turbulence;
- C Use spray/fog rinsing (less effective with hidden surfaces);
- C Use multiple rinse tanks in a counter-flow configuration (i.e., counter-current cascade rinsing); and

- C Reuse rinse water multiple times in different rinse tanks for succeeding less critical rinsing.

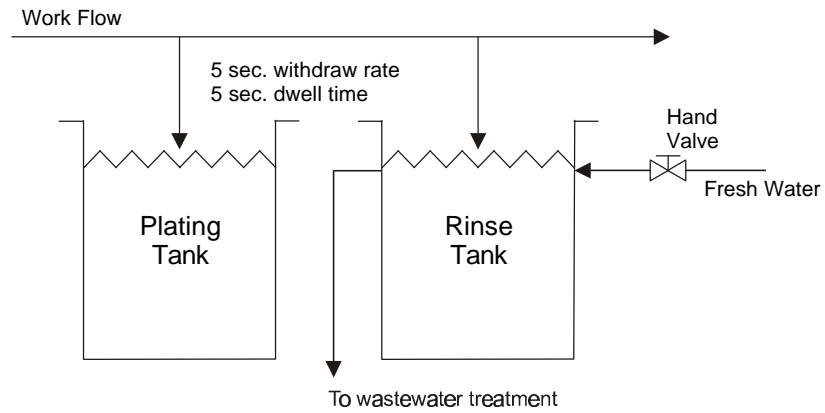


Figure 15-2a. Single Rinse Tank

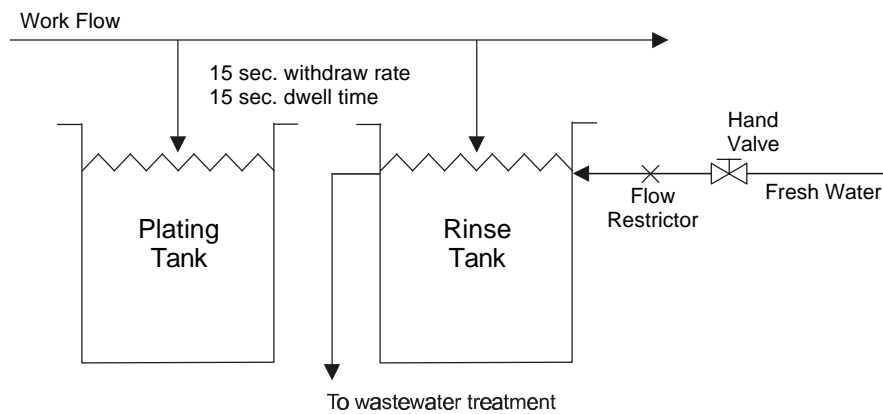


Figure 15-2b. Single Rinse Tank with Flow Reduction

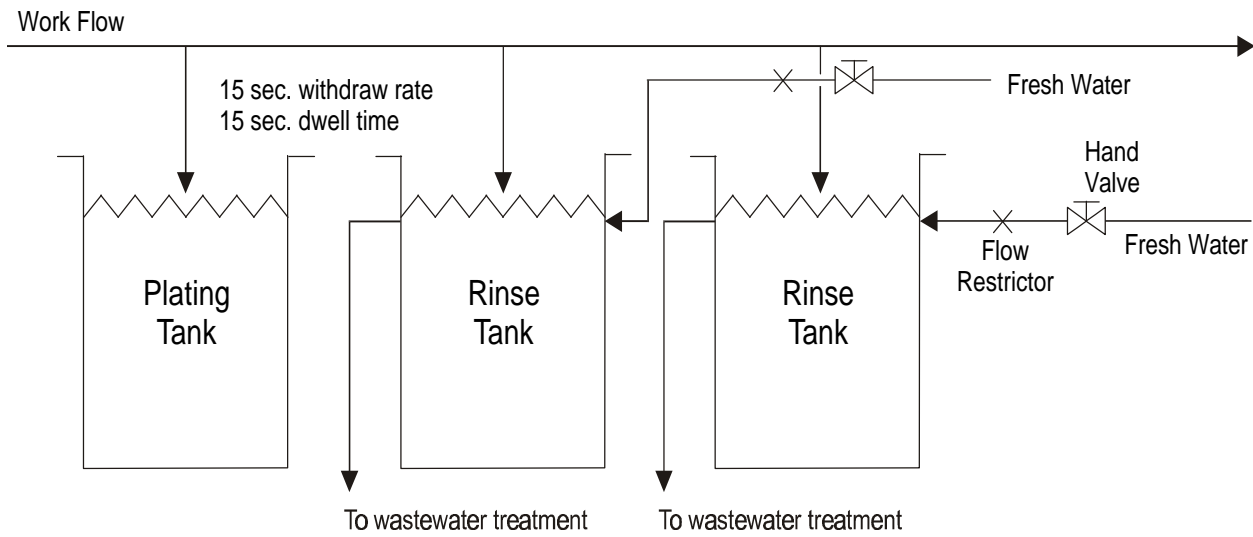


Figure 15-2c. Multiple Rinse Tanks with Flow Reduction

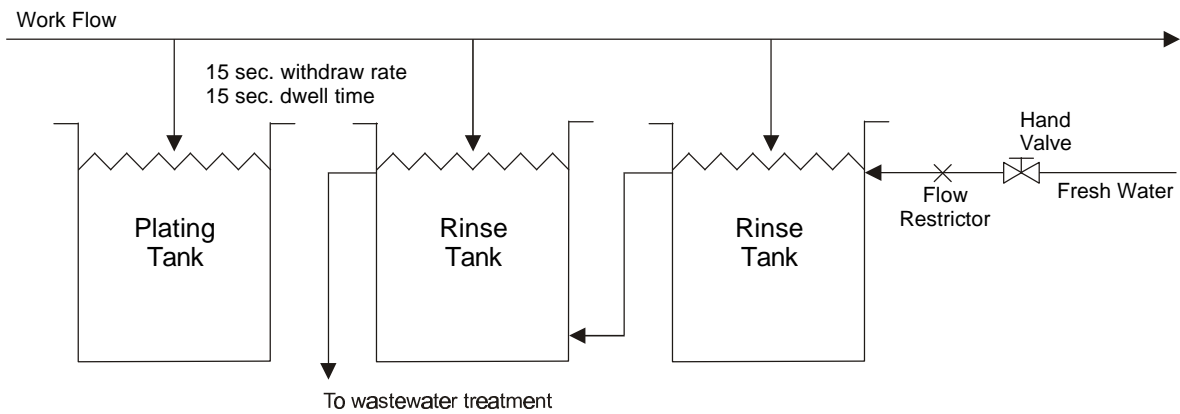


Figure 15-2d. Countercurrent Rinsing with Flow Reduction

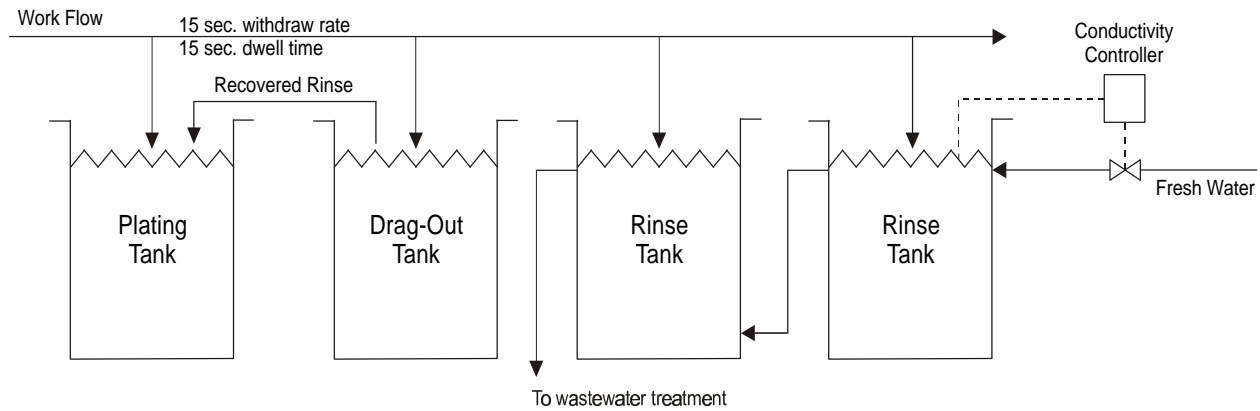


Figure 15-2e. Multiple Rinse Tanks with Flow Reduction and Drag-Out Recovery

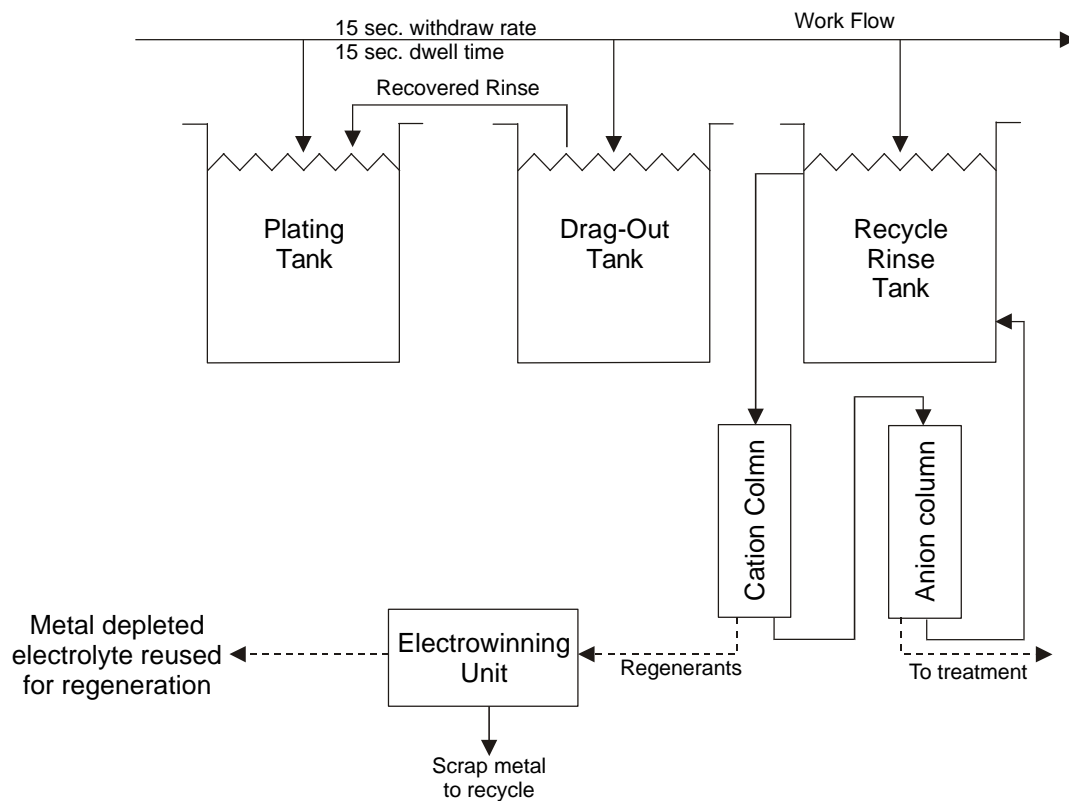


Figure 15-2f. Multiple Rinse Tanks with Water Recycle, Drag-Out Recovery, and Metal Recovery

Table 15-2 presents examples of additional practices and technologies that sites can implement to satisfy these criteria. Although most sites that implement these practices will conserve moderate to large amount of water, it is possible that excess water will still be used. If a permit writer or control authority suspects that excessive water is being used, they can verify this assumption by measuring the cleanliness or quality of the rinse water in the final rinse tanks by using a conductivity meter or by performing an analysis of total dissolved solids (TDS). See Section 15.3.2 for a listing of normal ranges of TDS for adequate rinsing. If the conductivity or TDS of a given rinse is lower than that of an industry-accepted criterion, then the facility may be using excessive water.

15.3.2 Influences on Flow Rates

Available data show that rinsewater-use rates are related to production when measured in terms of the surface area of parts processed. Other factors that influence rinsewater use rates include the drag-out rate (gallons per 1,000 square feet of workload), the rinsewater purity criteria (mg/L TDS or conductivity), the concentration of TDS in the bath (mg/L TDS), rinse tank design and configuration (e.g., single overflow rinse versus countercurrent cascade rinse), and the type of rinsewater flow control (e.g., manual versus conductivity controlled). Section 15.3.1 discusses drag-out rinse tank design and configuration, and rinsewater flow control. The other factors are discussed below.

Rinsewater Purity Criteria. Rinsewater purity criteria are the levels of tolerable contamination in the rinsewater. These levels vary for different processes and types of products. For example, rinsewater used after cleaning typically does not have to be as pure as rinsewater used following plating, since rinsewater that remains on the plated part (essentially the drag-out from the rinse tank) will leave spots after it evaporates if the concentration of dissolved solids in the rinsewater is too high. Although preliminary and intermediate processing steps such as cleaning and etching usually do not require as pure a rinsewater as final rinsing, the rinse water needs to be pure enough to stop chemical reactions (e.g., etching) and prevent the contamination of subsequent process solutions. Among plating processes, differences also exist in rinsewater quality requirements. Parts plated for engineering or functional purposes (e.g., corrosion resistance) can often be rinsed in water that is significantly less pure than decoratively plated parts rinses.

High-purity water is needed for various rinsing operations. In some cases (e.g., electronics parts rinsing), tap water is not pure enough to serve as rinsewater. Before use as rinsewater for this type of operation, the source water is purified by reverse osmosis and/or ion exchange to remove dissolved solids and other constituents. Source water is sometimes treated even for common rinsing operations, especially when the water supply is high in dissolved solids.

The metal finishing industry has had rinsewater quality requirements for decades. They are typically expressed in mg/L of TDS or in conductivity or resistivity units (resistivity is the inverse of conductivity). The following table summarizes some generalized rinse criteria found in the literature (1).

Generalized Rinse Criteria

Type of Rinse	Normal Range for Adequate Rinsing (mg/L TDS)
Alkaline Treatment/Acid Treatment Rinse	400 to 1,000
Functional or Engineering Plating Rinse	100 to 700
Decorative or Bright Plating Rinse	5 to 40

Source: Reference 1.

Permit writers or control authorities can use these criteria as a tool to assess water use practices at a given site.

Bath Concentration. The concentration of a bath (which can be expressed in g/L TDS) will affect the quantity of water needed for good rinsing. Baths that are more concentrated (i.e., higher TDS) will require more rinsewater to meet the same rinsewater purity criteria as a less concentrated bath. The bath concentration depends on the type of bath. For example, a typical acid zinc electroplating bath will have a TDS concentration of 166 g/L and a typical copper cyanide electroplating bath will have a TDS concentration of 250 g/L (3,4). For equal volumes of drag-out from these two baths, the copper cyanide rinse flow must be 1.5 times greater to achieve the same rinse quality criteria (i.e., $250/166 = 1.5$). This calculation does not account for the differences in viscosity that will also affect the volume of drag-out. For example, for flat surfaces, the drag-out rate for a 396-g/L chromic acid bath is 3.8 times greater than that of a 247-g/L bath (3,4). In some cases, the TDS concentration of the bath inadvertently increases due to a buildup of bath contaminants (e.g., iron may accumulate in a chromic acid bath due to the attack of the base metal). The TDS added by the contaminants may affect the drag-out rate in the same manner as its intended bath constituents (e.g., chromic acid). Therefore, operating a bath at the lowest concentration necessary to perform the job properly and maintaining bath contaminants at low levels is a significant pollution prevention measure.

15.3.3 Guidance for PNF Selection

The PNF has a significant impact on the maximum allowable process water flow. Due to the number of product/process variables that influence the PNF, permit writers or control authorities may select different PNFs for different sites, or different PNFs for different occurrences of the same operation within a site. The purpose of this section is to present available data and information to support the permit writer or control authority in determining an appropriate water-conserving PNF for an operation. The data sources are the MP&M surveys, technical literature, and the MP&M sampling program.

Most sites should be able to achieve PNFs at the lower end of the ranges presented in Table 15-1 when countercurrent cascade rinsing is implemented. Sites that are unable to implement countercurrent cascade rinsing (e.g., due to space limitations in a plating line) can usually reduce their water use by implementing other flow reduction techniques (e.g.,

ion-exchange recycling for electroplating rinses, flow restrictors combined with conductivity meters for other rinses). EPA included water-conserving practices in evaluating the cost impacts of regulation for sites affected by the proposed MP&M effluent guidelines. Section 11 discusses estimated compliance costs.

Certain specific conditions may affect a site's ability to reduce its water use. The drag-out rate may be higher than average or the rinsewater purity criteria may be lower than average. Guidance for identifying such conditions is presented below.

A conservative estimate of an average drag-out rate is 3.2 gallons/1,000 square feet of surface area (1). Higher drag-out rates may require greater rinsewater flows to achieve good rinsing. An accurate method of drag-out measurement is to track the concentration of a metal ion (or other sufficiently concentrated ion) in the rinse tank through a rinsing event. The facility can use the rise in concentration of the ion in the rinse tank to calculate the volume of process fluid introduced during the rinse if the concentration of that ion in the process fluid is known.

For example, a sample of a copper sulfate process bath is collected and analyzed for copper concentration along with two rinse samples--one before and one after a rinsing event. The drag-out volume for the rinsing event is:

$$D = \frac{(C_{\text{after}} - C_{\text{before}})}{C_p} \times V_r \quad (15-3)$$

where,

C_{after}	=	Concentration of selected metal ion in rinse tank after rinsing event (g/L)
C_{before}	=	Concentration of selected metal ion in rinse tank before rinsing event (g/L)
C_p	=	Concentration of selected metal ion in the process tank (g/L)
V_r	=	Volume of rinse tank in liters (L); and
D	=	Volume of drag-out in liters (L).

Several data points should be collected. Once a drag-out rate per unit area is derived, the PNF for the rinse system is:

$$\text{PNF} = \frac{(P / D)}{C_{r(\text{ave})}} \times C_{p(\text{ave})} \quad (15-4)$$

where,

P	=	Production rate (ft ²);
D	=	Drag-out rate (L);

$C_{r(ave)}$	=	Average target metal ion concentration in rinse tank (g/L);
$C_{p(ave)}$	=	Average target metal ion concentration in process tank (g/L); and
PNF	=	Production-normalized flow (L/ft ²).

Drag-out also can be measured using only a conductivity meter, by observing the effect that a controlled amount of process fluid has on the conductivity of a unit volume of rinsewater, and then applying these data to an actual rinsing event.

For example, the conductivity of one liter of fresh rinsewater should be measured, then again after adding and thoroughly mixing 1 milliliter of process fluid. The difference between the two measurements should be noted. Then the conductivity of a rinse tank should be measured prior to and after a rinsing event. The flow through the rinse tank must be closed during the test. The drag-out volume, in liters, for the rack or barrel and parts that were rinsed is:

$$D = \frac{(C_{\text{after}} \& C_{\text{before}})}{C_{\text{mix}} \& C_r} \times V_r \quad (15-5)$$

where,

C_{after}	=	Conductivity in rinse tank after rinsing event;
C_{before}	=	Conductivity in rinse tank before rinsing event;
C_{mix}	=	Conductivity in mixture of 1 ml of process fluid and 1 liter of fresh rinsewater;
C_r	=	Conductivity of fresh rinsewater;
V_r	=	Volume of rinse tank (L); and
D	=	drag-out rate in liters (L).

Several data points should be collected.

Rinsewater purity criteria vary for different processes. Average purity criteria for rinsing following cleaning, functional surface finishing, and decorative surface finishing are 700 mg/L, 400 mg/L, and 22.5 mg/L, respectively. If a site indicates that their surface finishing process requires purer rinsewater, then the permit writer or control authority may choose to use additional resources to select an appropriate flow rate. Often, the permit writer or control authority can identify sites that require purer rinsewater due to their use of softened or deionized water for rinsing. They may test a site's rinsewater to help assess their actual requirements, with the premise that their required water purity criteria is no lower than the existing purity level in the rinse tanks. Testing would involve collecting composite samples from the final rinse tank following each unit operation and analyzing them for TDS.

The following are additional resources that the permit writer or control authority can use to select an appropriate flow rate when the drag-out rate is higher than average or purer rinsewater is necessary.

Technical Literature. One source of data to use in identifying an appropriate flow rate for an operation is technical literature. Using the rinse water purity criteria along with the drag-out rates and the typical concentrations of TDS in various process baths, the permit writer or control authority can calculate a “literature” flow rate. Table 15-5 presents, for several types of rinses, calculated flow rates for a single-stage overflow rinsing configuration and a two-stage countercurrent cascade rinsing configuration. Both rinsing configurations are assumed to have flow control (i.e., water use is coordinated with drag-out introduction using a conductivity control or other device). This table presents the TDS concentration in the associated bath (from literature), the target TDS in the rinse (based on the rinsing criteria), the part type, the assumed drag-out rate, and two PNF values.

The first value, PNF 100% Control, is a calculated value based on the assumption that a site perfectly coordinates work flow and rinsewater use (e.g., using a conductivity controller). In actual operations, perfect coordination is nearly impossible to achieve because the quantity of rinsewater needed to meet a given rinse criterion usually cannot be added exactly at the time that drag-out enters and is dispersed in the rinse tank. For example, when a barrel of parts is rinsed, it is usually placed in a rinse tank for 1 to 3 minutes. The rinsewater volume needed to meet the rinse criterion may be 50 gallons or more. The flow rate of water into the rinse tank is typically less than 10 gpm (flow rates into rinse tanks vary depending on the pipe size and water pressure and may be reduced by a flow restrictor). Therefore, it may take 5 minutes to add the 50 gallons of rinsewater. Because of this, actual water use rates will be higher than those presented in the column, PNF 100% Control. A reasonable assumption is that good water flow control will result in a PNF twice that of the calculated values that assume 100% control. These flows are shown as PNF 100% excess.

The permit writer or control authority can use the rinsing configurations, drag-out rates, target total dissolved solid (TDS) concentrations, and equations provided in Table 15-5 to calculate other PNFs from literature sources.

MP&M Field Sampling Data. The permit writer may also find data from the MP&M field sampling program useful in selecting an appropriate PNF for a specific operation. For samples collected for this program, the Agency obtained flow and production data as well as a description of the pollution prevention and water conservation practices in place for several sampled rinses. Table 15-6 summarizes these data, collected at two MP&M sites, for countercurrent cascade rinsing operations (the recommended technology on which the MP&M technology options were based). This table also shows the type of process solution, the type of part processed through the rinse, an adjusted TDS, and an adjusted PNF. The adjusted TDS values are common rinsing criteria found in the literature. The adjusted PNF values were calculated using the adjusted TDS values and the equations presented with Table 15-5. Therefore, the adjusted PNF values are rinsewater flow rates that would be expected for these countercurrent cascade rinsing operations if they were to provide rinsewater quality equal to the adjusted TDS. The purpose of presenting these values is to demonstrate the reasonableness of the PNFs calculated based on literature values in Table 15-5.

15.4 Flow Guidance for Machining Operations

Many machining operations use metal-working fluids to cool and lubricate parts and machining tools during cutting, drilling, milling, and other machining operations. These fluids become contaminated and begin to lose their working characteristics. If neglected, the fluids become unusable and require treatment and disposal. Through proper care, the life span of the fluids can be extended indefinitely. For most machining operations, prolonging metal-working fluid life reduces the cost of treatment and disposal, as well as the cost of fresh coolant.

Section 15.4.1 provides background information to identify pollution prevention and water conservation practices applicable to machining wastewater and evaluation criteria to assess if a particular site has properly implemented these practices. Section 15.4.2 shows the influences on flow rates from machining operations. Section 15.4.3 presents guidance for selecting the appropriate flow rate for sites that do not have pollution prevention and recycling practices in place. The guidance is based on various factors that impact machining fluid requirements, including type of machining operation, base metal machined, and type of machining system.

15.4.1 Identification of Sites With Pollution Prevention and Water Conservation Practices

This subsection provides background information and guidance that the permit writer or control authority can use to determine if a site has implemented pollution prevention and water conservation practices for their machining operations. If the site has implemented pollution prevention and water conservation practices, the permit writer or control authority can use the concentration-based limitations to ensure compliance. If the site has not implemented these types of practices, the permit writer can use the information in this subsection to calculate the flow rates for developing mass-based limits (although not required).

Many MP&M sites use some type of pollution prevention and water conservation practices for machining wastewaters. Some sites have implemented numerous pollution prevention and water conservation methods and technologies that result in very low machining wastewater discharge rates and in some cases eliminate the discharge of machining fluids. Pollution prevention and water conservation practices are applicable to all machining operations; however, process-related factors and site specific conditions may restrict the utility of certain methods.

Wastewater Generation from Machining Operations

Various types of metal-working fluids, also termed cutting fluids and coolants, are used in machining operations to improve the life and function of machine tools. During machining, these fluids are circulated over working surfaces, reducing friction, cooling the tool and part, and removing metal chips from the work face. The type of fluid used depends on the type of machining being performed and the preference of the site. The fluids are broadly divided

into four groups: straight oil (neat oils), synthetic, semisynthetic, and soluble oil. The most commonly used fluids are soluble oils synthetics, and semisynthetics.

Water-soluble coolants are prepared by mixing a concentrated coolant with water in a 1:15 to 1:30 ratio to produce a fluid with a 90 to 98 percent water content. Most water soluble coolants are suitable for light- and medium-duty operations. Synthetic coolants are designed for high cooling capacity, lubricity, and corrosion prevention. Common chemical agents in synthetics include: amines and nitrites for rust prevention; nitrates for nitrite stabilization; phosphates and borates for water softening; soaps and wetting agents for lubrication; phosphorus, chlorine, and sulfur compounds for chemical lubrication; glycols to act as blending agents; and biocides to control bacteria growth. Semisynthetics contain small dispersions of oil in an almost otherwise organic water-dilutable system. Straight oils are good lubricants, but are less effective for cooling, and therefore are limited mostly to use in low-speed operations (8).

Metal-working fluids are periodically discarded because of reduced performance or development of a rancid odor. The fluids that contain a large percentage of oil typically are hauled as solid waste for disposal or recovery. Fluids with lower oil content typically are sent to a site's wastewater treatment system for treatment and subsequent discharge.

Metal-working fluids degrade mainly because of contamination with tramp oil and dirt and by bacterial growth, which can be accelerated by tramp oil contamination. Tramp oil contamination is caused mostly by oil from the part's surface during machining and by leaks of lubricating and hydraulic oils from the machine. Airborne dust or poor housekeeping practices can cause dirt to accumulate. Bacteria are initially contributed from the surfaces of the machine and parts and from the air. More than 2,000 known species of bacteria have been reported to affect and eventually destroy the stability of machining fluids (5). Bacteria feed on the fluids' chemicals, causing the fluids to lose lubricity and corrosion inhibition. Under anaerobic conditions, sometimes caused by floating tramp oil in coolant sumps, bacteria generate a hydrogen sulfide odor.

In addition to spent fluid, machining operations may generate wastewater from rinsing. Machined parts may be rinsed to remove fluid, chips and other foreign materials. However, parts typically are not rinsed following machining. More frequently, the fluid is permitted to remain on the part to inhibit corrosion, is wiped off using shop towels, or is cleaned in an alkaline cleaning or degreasing operation.

The quantity of wastewater generated by a machining operation depends primarily on the volume of work performed. Production volume can be roughly measured by the quantity of metal stock removed by turning, milling, boring, broaching, cutting and other machining operations. For most machining operations, the removed metal consists of small fragments called chips or fines. Most chips carry a thin film of fluid on their surfaces, which, when it drains, is another source of wastewater.

Pollution Prevention and Water Conservation Practices for Machining Operations

The Agency has identified two categories of pollution prevention and water conservation practices and technologies that can be applied to reduce metal-working fluid discharge: those used to prevent metal-working fluid contamination and those used to extend the life of machining fluids, including recovering and recycling metal-working fluids. Within each of these categories are several specific practices and technologies. Table 15-7 presents several examples of these practices, which are discussed below.

Prevention of Metal-Working Fluid Contamination. Sites can implement various methods to reduce the amount of fluid contamination. Several of these methods are discussed below.

Reduction of Contamination From Tramp Oil. Tramp oil is a primary contaminant in machining fluids and for many sites the major cause of metal-working fluid degradation. The Agency has identified the following methods to reduce contamination of metal-working fluid with tramp oil.

- C Use of Coolant in Hydraulic and Other Oil Systems. Some metal-working coolants are formulated to be used as hydraulic fluid and/or lubricant in concentrated form, and as a coolant in its dilute form (i.e., diluted with water). When used as a hydraulic fluid or lubricant, leaks of the fluid will be assimilated into the coolant without causing contamination.
- C Replacement of Hydraulics with Electrical Systems. Hydraulic systems on some machines can be replaced by newer electrical systems that do not contain hydraulic fluid. This replacement could be economically performed during major equipment overhauls.
- C Machine Maintenance. Machine design and age may affect the quantity of hydraulic oil that leaks to the metal-working fluid during machining operations. There are numerous hydraulic systems used with machines, depending on the type of machine. These systems will leak variable quantities of oil depending on design, sealing mechanisms, operating pressures, and other factors. Older machines, especially those that are not properly maintained, can have excessive leaking from hydraulic seals. Sites should implement scheduled maintenance of machines to check and repair sealing mechanisms.

Reduction of Contamination from Makeup Water. Makeup water contributes to the dissolved solids content of the metal-working fluid, reducing fluid life. This problem occurs more rapidly when water with high TDS is used for evaporative makeup. Certain dissolved solids or minerals cause more problems for metal-working fluids than others. For example,

chloride salts and sulfates corrode at levels of greater than 100 parts per million. Sulfates also promote the growth of sulfate-reducing bacteria that cause fluids to become rancid. When minerals become concentrated in the fluid, they can cause increased corrosion, gumming, and machine wear (8). Consequently, using hard water can reduce the fluid life. Deionized (DI) water can be used in place of hard water (DI units can be either purchased or rented).

Reduction of Contamination from Sumps. The Agency has identified the following methods to reduce contamination from metal-working fluid sumps:

- C Steam Cleaning of Sumps. Machine coolant sumps harbor bacteria that degrade the fluids. If coolant sumps are not sterilized during clean-outs, the fresh coolant added to cleaned sumps may be degraded by residual bacteria. Bacteria from sumps can be eliminated by steam cleaning during clean-out.
- C Sump Modification. Many coolant sumps are designed as in-ground concrete tanks, whose porous concrete surfaces absorb oil and promote bacterial growth. Fluid life may be extended by improving the design of the sumps. Potential design changes include inserting metal tanks and coating sump walls with fiberglass or other non porous material.

Reduce Miscellaneous Contamination. Good housekeeping practices can extend metal-working fluid life by reducing contamination. Sites can implement housekeeping procedures to keep floor sweepings, solvents, paint chips, soil, rags, paper, and other debris out of the coolant sumps.

Extension of Metal-Working Fluid Life. Sites can implement several methods to extend the life of metal-working fluids. These include raw material substitution, equipment modification, and fluid monitoring, as discussed below.

Raw Material Substitution. As discussed above, four general types of metal-working fluids are used in machining operations. Within a given group of fluids, such as soluble oil, various formulations are used. Within each group, the major difference from one fluid to another is the “additive package.” Additives are included in most metal-working fluid formulations to improve fluid performance (e.g., improve lubricity, reduce friction, or increase corrosion protection) and increase life span (e.g., reduce bacterial growth). Costs of different metal-working fluids can vary by 100% or more. Fluids with additive packages that do not meet the lubrication and cooling requirements of the specific machining operation may degrade faster than other metal-working fluids. These fluids will need to be replaced more often and increase overall operating costs. These fluids may also affect tool life, further increasing operating costs. Therefore, using the proper grade metal-working fluids can increase the life span of the fluid, reducing the generation of waste machining fluids and decreasing the overall operating costs.

Equipment Modification. The Agency has identified the following types of equipment modifications that can extend the life of machining fluids.

- C **Replacement of Air Agitation With Mechanical Agitation.** Some sites use air agitation in central coolant sumps to constantly mix the fluid and prevent phase separation and pooling of tramp oil. However, air agitation increases the activity of aerobic bacteria by adding oxygen, which causes the bacteria to consume fluid additives. An alternative method of mixing is mechanical agitation (i.e., pumping). Mechanical agitation mixes without increasing the oxygen concentration of the coolant.
- C **Removal of Tramp Oil.** Machining fluid life can be extended by continuous, in-sump removal of tramp oil. Sites can install continuous oil-skimming devices directly in the machine sump to remove tramp oil. Tramp oil can also be removed using absorbent blankets, fabrics, or pillows.

Fluid Monitoring. During use, the metal-working fluid undergoes various physical, chemical, and biological changes. If the properties of the fluid are monitored on a regular basis, the fluid can be adjusted before it is degraded. Parameters measured to monitor the fluid include: pH, coolant concentration (using a refractometer or titration kit), TDS, tramp oil (visual) and biological activity (using dip slides available from coolant suppliers and laboratories (3) or other methods). These data can be used to guide periodic fluid adjustments and/or develop statistical process control (SPC) procedures. Fluid concentration should be monitored at least weekly, if not daily. The correct pH operating range of most coolants is 8.5 to 9.5. If the pH drops below the operating range, coolants may cause rusting and be prone to increased biological activity. Dilute concentrations can shorten tool life, increase biological activity, and cause rust. Rich concentrations can lead to foaming and tramp oil contributes to biological growth.

Metal-Working Fluid Recycling. Most metal-working fluids can be recycled on site by removing contaminants accumulated during use and storage. Recycling methods include settling, straining, skimming, simple filtration, membrane filtration, coalescing, centrifugation, cyclone separation, magnetic separation, and pasteurization. Some of these methods can be used in combination to recover nearly 100% of the metal-working fluid. Sites can purchase recycling equipment or hire commercial services that perform on-site processing (6,7,23). A self-contained recycling unit can be purchased that is specifically designed for smaller machine shops and is a complete sump maintenance and fluid recycling system in one unit (8). In most cases, sites can facilitate metal-working fluid recycling by consolidating the types of machining fluids they use to one or two types of fluid.

Additional metal-working fluid can be recycled by chip drainage. Chip drainage can account for up to 50 percent of annual fluid use (7). During machining, the metal chips (scraps) become coated with fluid. Part of the fluid drains from the chips and part remains on the chips. In many cases, the chips and associated fluid are dropped to the floor and manually

collected in storage containers. Some machines send the chips and fluid to a storage container using automated equipment (e.g., belt or pneumatic conveyor). Fluid that drains from chips can be recycled rather than discharged, which may require design changes of chip handling and storage equipment.

Evaluating Metal-Working Fluid Use at a Site

To identify sites with pollution prevention and water conservation practices in place for machining operations, the permit writer or control authority should focus on the categories of practices discussed above. Specifically, sites should pass both of the following criteria for the majority of machining operations on site:

- C The site should use practices and/or technologies to prevent contamination of the metal-working fluid; and
- C The site should use some type of practice or technology to extend the life of the metal-working fluid.

Table 15-7 presents examples of practices and technologies that sites can implement to satisfy these criteria.

15.4.2 Influences on Flow Rates

Available data show that wastewater discharge rates from machining operations are a function of production when measured in terms of the mass of metal stock removed by the machining operations (see Table 15-1). Wastewater discharge rates are also affected by other factors that cause PNFs to vary from site to site. The most important of these factors are the type of metal-working fluid used, the design of the machine fluid system, the machining operations performed, and the fluid management practices used. Other factors include base material being machined, climatic conditions, design and age of machines, and chip storage methods. Sites control several of these factors (e.g., type of metal-working fluid, fluid management practices, and chip storage methods) by implementing pollution prevention and water conservation practices and technologies. The other factors are, to a degree, beyond the control of the site and will affect the minimum flow rate achievable by a site. The effects of several of these factors on flow rates are discussed below.

Design of the Machine Fluid System. Fluids used in machining are stored either in sumps dedicated to individual machines (either internal or external to the machine), or in central sumps that serve multiple machines. Large machining operations typically use central sumps, whereas small machine shops tend to have individual sumps for each machine. Central systems usually contain three to five times greater volume of fluid per machine from individual sumps. The reservoir volumes of most machines with internal sumps are typically 10 to 50 gallons. External sumps serving a single machine typically have a volume of 1,000 to 2,500 gallons. Central sumps may have volumes that exceed 50,000 gallons.

The amount of make-up fluid in a central system amounts to a smaller percentage of total fluid than in a single machine operation. Consequently, the potential for bacterial degeneration is greater in central systems as the bacteria have a longer time in which to attack the fluid (5). Further, central sumps are often unlined concrete basins, whose porous walls hide bacteria and prevent complete disinfecting during clean-outs. This reduces the time needed for the bacteria to become reestablished (7). Additionally, the larger pumps used in central systems keep the tramp oils suspended in the fluid so they do not readily “float out,” adding to further bacterial attack. Central systems may require more maintenance than dedicated sumps to prevent bacterial growth.

Machining Operations Performed. The ratio of scrap metal (e.g., chips) generated to fluid used varies among machining operations. For example, metal cutting may generate large pieces of scrap metal using a small volume of fluid, whereas a milling operation usually produces a much smaller mass of chips for the same volume of fluid. However, based on the MP&M survey database, EPA did not identify any trends in PNF across types of machining operations performed.

Base Material Being Machined. The type of base material being machined affects the quantity of metal-working fluid used. The hardness of base materials varies, which in turn affects the speed at which the base metal can be removed. Harder metals require more fluid than softer metals for the same operation.

Climatic Conditions. The temperature of the shop can affect the life span of metal-working fluid in that warmer temperatures may foster the growth of certain bacteria.

Design and Age of Machines. The design and age of machines may affect the quantity of hydraulic oil that is leaked to the metal-working fluid during machining operations. Numerous hydraulic systems are used with machines. These systems will leak variable amounts of oil depending on design, sealing mechanisms, operating pressures, and other factors. Older machines, especially those that are not properly maintained, can have hydraulic seals that excessively leak.

Uniform Coolant Use. Minimizing the number of different machine coolants used at a facility and reduces the chance of formulation errors. When employees are familiar with fluid properties and coolant formulation chemistry, it is less likely that coolant batches will be prepared incorrectly, which many times requires the entire batch to be discharged to the on-site wastewater treatment facility. Facilities may also save money by purchasing larger volumes of coolant (i.e., economies of scale).

15.4.3 Guidance for PNF Selection

The following table presents PNF data (summarized from Table 15-1(b)) from the MP&M surveys for machining operations. Data are in gallons of wastewater (i.e., primarily spent coolant and associated rinsewater, if used) discharged per pound of metal removed.

PNFs For Machining Operations

Minimum PNF	10th Percentile	25th Percentile	Median PNF	75th Percentile	90th Percentile	Maximum PNF	Mean PNF
0.0003	0.011	0.05	0.12	0.18	1.68	376	1.6

Source: MP&M Detailed Survey Database.

As shown in this table, the PNFs for machining operations range over several orders of magnitude. Based on data gathered from the MP&M surveys, site visits, and technical literature, the Agency believes that the wide range of PNFs indicates the variety and extent of pollution prevention practices in use at MP&M sites (e.g., sites with coolant maintenance and recycling practices in place versus sites without these practices in place).

For sites that do not have pollution prevention and recycling systems in place for machining operations, the permit writer or control authority can use the PNF data to estimate target flows. The permit writer can multiply the daily amount of metal (lbs) processed through all machining operations by the median PNF (gal/lb) to determine the site's target daily flow (gal/day).

The Agency believes that most sites can reduce their flow rates to levels at or below the median PNF for machining operations by implementing one or more of the pollution prevention and water conservation practices discussed previously. Site-specific conditions may limit the ability of certain sites to reduce their flow rates.

15.5 Flow Guidance for Painting Operations

Paint is applied to a base material for protective and decorative reasons in various forms, including dry power, solvent-diluted formulations, and water-borne formulations. Various methods of application are used, the most common being immersion and spraying. Water is used in painting operations in paint booth water-wash systems (water curtains), in water-borne formulations, in electrophoretic painting solutions and rinses, and in clean-up operations. This discussion is directed at water use in spray painting booths; however, this subsection also provides some information on rinsing following electrophoretic painting and water clean-up.

Section 15.5.1 presents background information to identify pollution prevention and water conservation practices applicable to painting operations. This includes discussions of wastewater generated from painting operations, and practices and technologies that can be implemented to reduce wastewater discharges. Section 15.5.2 discusses influences on flow rates. Section 15.5 presents guidance for selecting appropriate flow rates for sites that do not have pollution prevention and water conservation practices in place. The guidance is based on various factors that impact water use requirements.

15.5.1 Identification of Sites With Pollution Prevention and Water Conservation Practices

This subsection provides background information and guidance that the permit writer or control authority can use to determine if a site has implemented pollution prevention and water conservation practices for painting operations. If the site has implemented pollution prevention and water conservation practices, the permit writer or control authority can use the concentration-based limitations to ensure compliance. If the site has not implemented pollution prevention and water conservation practices, the permit writer or control authority can use the information in this subsection to calculate the flow rates for developing mass-based limitations.

Wastewater Generation from Painting Operations

In spray painting, an organic coating is applied to a product. During manufacturing operations, spray painting is usually performed in a booth to control the introduction of contaminants and the release of solvent and paint to the work place and environment, and to reduce the likelihood of explosions and fires. Paint booths are categorized into two types (dry-filter or water wash) by the method of collecting the over spray (i.e., the paint that misses the product during application). The type of booth designs selected depends mainly on production requirements, including part size and configuration, production rate and transfer efficiency, the material being sprayed, and finish quality requirements.

Dry-filter booths use filters to screen out the paint solids, by pulling prefiltered air through the booth, past the spraying operation, and through the filter. The air entrains the overspray and is pulled through the filter, which collects the paint. Solvent evaporates from the paint, leaving the paint solids on the filter. Filters are periodically replaced when they become laden with paint solids and the air flow through them is restricted. Dry-filter booths are most often used when paint usage does not exceed 20 gallons/8-hour shift/10 feet of chamber width (14). At higher usage rates, the frequency of filter changes greatly increase operating costs (i.e., filter, filter disposal, and labor).

The only water used with dry filter units is to clean painting equipment (e.g., guns and lines) when water-borne paints are used. The operation of dry-filter units is essentially dry when solvent-based paints are used.

Water-wash booths use a “water curtain” to capture paint overspray. Air containing entrained paint overspray is pulled through a circulating water stream, which “scrubs” the overspray from the air. There are two primary types of water-wash booths, side-draft and downward-draft. The basic difference between the two types is the way the air moves through the system to draw the paint overspray in for capture (15,16). Side-draft units are typically used by small painting operations and the downward-draft units are used with large and/or continuous operations.

Water-wash booths use a water stream that recirculates from a sump or tank with a typical capacity of 200 to 5,000 gallons or more. Downward-draft systems normally contain much larger volumes of water than side-draft systems. Water is periodically added to the system as make-up for evaporative losses. The sump water is periodically discharged, usually during general system cleaning or maintenance. The discharge rate depends on various factors, including booth design, paint type, overspray rate, and the water treatment methods used. Water is also used to clean the painting equipment and the paint booth. Booth cleanup may involve using paint stripper to remove dried paint from the walls of the booth and the piping system.

A common practice in water-wash booth operation is to immediately detacify suspended paint solids to reduce maintenance problems and to subsequently separate and remove the solids from the water. The organic resins that make up the bulk of the paint coating are insoluble in water and tend to stay tacky if not treated with some other material added to the water (15,16). If left untreated, the tacky solids can plug recirculation pipes and pumps and adhere to wetted surfaces of the booth. Dissolved solids are either immediately precipitated and flocculated, removed by water treatment, or discarded when the sump is discharged.

Solids can be detacified and removed in various ways, depending on the type of paint used and the booth design. Detacification chemicals include sodium hydroxide (caustic), metal salts, clay, and polymers. Depending on the type of paint and the detacification chemical, the paint solids may either disperse or agglomerate. Agglomerated solids may either sink or float. In solids dispersal, the suspended solids increase in concentration as over spray enters the water. Subsequently, another chemical is added to the water that causes the dispersed solids to agglomerate into a dense floc, which is then removed.

Paint solids are removed from the booth water-wash system by various means. These removal technologies vary in sophistication, automation, efficiency (removal and separation), and capital and operating costs. The most common methods include passive settling, skimming, screening, filtration (bag, roll bed, press), and centrifugal methods (hydrocyclone, centrifuge).

Another common method of painting is electrophoretic painting (also known as electrocoating or electrodeposition), which is the process of coating a work piece by making it either anodic or cathodic in a bath that is generally an aqueous emulsion of the coating material. The electrophoretic painting bath contains stabilized resin, pigment, surfactants, and sometimes organic solvents in water. Electrophoretic painting is used primarily for primer coats (e.g., bodies for motor vehicles or mobile industrial equipment) because it gives a fairly thick, highly uniform, corrosion-resistant coating in relatively little time. During this process, precleaned parts carrying an electrical charge are immersed into the coating tank (paint) and then through a rinsing system. Rinsing removes excess paint (drag-out) from the parts. The typical rinsing procedure is a three-stage countercurrent rinse, and may include both dip and spray rinsing. Typically, the final rinse is performed with deionized water.

Ultrafiltration is commonly used to separate and recover paint solids and recycle rinsewater, by counter flowing the rinsewater into the painting bath and filtering the bath with ultrafiltration. The ultrafilter removes excess water from the bath, recycles the paint solids to the bath, and recycles the water (permeate) to the rinse system. Occasional blowdown of rinse water is needed to purge the system of contaminants. The volume of wastewater discharged can be reduced by processing the rinsewater through a reverse osmosis unit (17).

Pollution Prevention and Water Conservation Practices for Painting Operations

The Agency has identified three categories of pollution prevention and water conservation practices that sites can implement to reduce or eliminate wastewater discharges from painting operations: practices to reduce the quantity of paint entering the water system; recycling technologies for paint booth water; and conversion of water-wash booths to dry-filter booths. These are discussed in this subsection and summarized in Table 15-8.

Reducing the Quantity of Paint Entering the Water System. Sites can implement various methods to reduce the quantity of paint entering the water system. Three of these methods are discussed below.

Improving Spray Painting Operating Practices. Sites can implement various practices that reduce the quantity of paint and other material entering the water system of a paint booth and thereby reduce the need to discharge wastewater. Generally, implementing these practices only requires operator training. These practices include: racking and positioning parts to minimize over spray; selecting the proper nozzle for an efficient spray pattern; scheduling work to reduce color changes and associated clean-outs of guns, lines, and pots; and housekeeping to prevent painting wastes and foreign materials from entering the booth's water system.

Improving Transfer Efficiency. The transfer efficiency (i.e., spray efficiency) is the amount of coating that is applied to the part divided by the amount of coating that is sprayed from the gun. It is reported as a percentage. The transfer efficiency depends on several factors, including the spraying equipment, part size and configuration, paint type, and operating methods. By improving the transfer efficiency, booth water processing requirements can be reduced.

During the past 15 years, spraying equipment has improved, primarily in response to more stringent air pollution regulations and rising paint costs. One of the key improvements has been replacement of conventional compressed air spray equipment by more efficient equipment. In terms of transfer efficiency, the common types of spray equipment are ranked as follows (shown in order of increasing efficiency with relative transfer efficiencies shown in parenthesis): conventional compressed air (25%), airless (35%), air assisted airless (45%), electrostatic, (65%), and high-volume/low-pressure (HVLP) (80%) (12). The HVLP equipment has been widely implemented due to the high transfer efficiency, as well as the low cost of converting from conventional compressed air equipment. The cost is primarily for the spray

guns, since the compressors and other equipment are the same as for conventional compressed air painting equipment.

Installing Gun Cleaning Station. After use, spray-painting equipment must be cleaned to prevent a buildup of paint solids. Spray guns are often cleaned by spraying solvent through the lines and guns and into the booth. However, this practice increases the amount of paint entering the booth's water system and increases emissions of volatile organic compounds (VOCs). An alternative practice is to install gun-cleaning stations. A commercial gun-cleaning unit is designed to sit on top of a 55-gallon drum. The gun is connected to the solvent tank and the drum. Solvent is drawn through the gun and exits into the drum, where it can be recovered by distillation (9).

Booth Water Recycle. Various methods and equipment can reduce or eliminate the discharge of the water used in water-wash booths. These methods and equipment prevent the continuous discharge of booth waters by conditioning (i.e., adding detacifiers and paint-dispersing polymers) and removing paint solids. The least efficient paint booth water-wash system, in terms of water use, is one where the paint solids are not conditioned and accumulate until booth water must be replaced. Cleaning such systems typically involves draining or pumping the water from the booth reservoir and contract hauling the entire waste product. Due to high operating costs and downtime, this procedure is usually used only by low production operations. With moderate- and high-production levels, daily, if not continuous, booth water maintenance is needed to conserve water. The most basic form of water maintenance is the removal of paint solids by manual skimming and/or raking. These solids can be removed without water conditioning since some portion of solvent-based paints usually floats and/or sinks. With the use of detacifiers and paint-dispersing polymer treatments, more advanced methods of solids removal can be implemented. Some common methods are discussed below.

Wet-Vacuum Filtration. Wet-vacuum filtration units consist of an industrial wet-vacuum head on a steel drum containing a filter bag. The unit vacuums paint sludge from the booth. The solids are filtered by the bag and the water is returned to the booth. Large vacuum units are also commercially available that can be moved from booth to booth by forklift or permanently installed near a large booth.

Tank-Side Weir. A weir attached to the side of a side-draft booth tank allows floating material to overflow from the booth and be pumped to a filtering tank for dewatering (15,16).

Consolidator. A consolidator is a separate tank into which booth water is pumped. The water is then conditioned by adding chemicals. Detacified paint floats to the surface of the tank, where it is skimmed by a continuously moving blade. The clean water is recycled to the booth (15,16).

Filtration. Various types of filtration units are used to remove paint solids from booth water. The booth water is pumped to the unit where the solids are separated, and the water

is then returned to the booth. The simplest filtration unit consists of a gravity filter bed with paper or cloth media. Vacuum filters are also used, some of which require precoating with diatomaceous earth (15,16).

Centrifuge Methods. Two common types of centrifugal separators are the hydrocyclone and the centrifuge. The hydrocyclone is used to concentrate solids. The paint booth water enters a cone-shaped unit under pressure and spins around the inside surface. The spinning increases the gravity, which causes most of the solid particles to be pulled outward to the walls of the cone. Treated water exits the top of the unit and the solids exit the bottom. Some systems have secondary filtration devices to further process the solids. The centrifuge works in a similar manner, except that the booth water enters a spinning drum, which imparts the centrifugal force needed to separate the water and solids. Efficient centrifugation requires close control of the booth water chemistry to assure a uniform feed. Also, auxiliary equipment such as booth water agitation equipment may be needed.

Conversion of Water-Wash Booths to Dry-Filter Booths. Water-wash booths can be converted to or replaced by dry-filter booths. The dry-filter booths have the potential to eliminate the wastewater discharge, but they create a solid wastestream. The choice between using a water-wash booth or a dry-filter booth is primarily based on the amount of over spray. It is usually cost-effective to use a dry-filter booth when paint usage does not exceed 20 gallons/8-hour shift/10 feet of chamber width (14).

A 1989 U.S. Navy study concluded that conversion from wet to dry booths can be cost-effective for a range of operations. This study included a survey of military and industrial facilities that have successfully been converted and an economic analysis based on typical Navy painting operational parameters (19).

Evaluating Water Use for Painting Operations

To identify sites with good painting-related water use practices, a permit writer or control authority should focus on the categories of these practices discussed above. Specifically, sites should meet both of the following criteria for the majority of painting operations on site:

- (1) The site should use practices and/or technologies to reduce the amount of paint entering the water system; and
- (2) The site should use some type of practice or technology that minimizes or eliminates the discharge of wastewater by recycling the water used during painting or replacing existing wet systems with dry systems.

Table 15-8 presents examples of practices and technologies that sites can implement to satisfy these criteria.

15.5.2 Influences on Flow Rates

Available data show that wastewater discharge rates from painting operations are a function of production when measured in terms of the surface area of parts painted (see Table 15-1(a)). Wastewater discharge rates are also affected by other factors that cause PNFs to vary from site to site. Some sites are able to operate without a wastewater discharge, while others have a wide range of PNFs. The most important of these factors are the paint transfer efficiency, booth type and reservoir size, maintenance requirements of the booth, the booth water chemistry and water recycling methods used, and the chemical make-up of the paint being applied. Sites can control a few of these factors (e.g., paint transfer efficiency and the booth water chemistry and water recycling methods used) by implementing the proper pollution prevention and water conservation practices and technologies. The other factors are, to a degree, beyond control of the site and will affect the minimum PNF achievable by a site. The effects of several of these factors on PNF are discussed below.

Solvent, Paint Solids, and Other Components of Paint. The chemical make-up of the paint can impact the PNF. The recirculated water in a water-wash booth contains the various constituents of the paint(s) being applied. With most solvent formulations, the solvents (e.g., xylene, toluene, methylene chloride) are not water-soluble, but can be water-miscible. Some exceptions, such as acetone and methyl ethyl ketone (MEK), are water-soluble. However, in most cases, the solvents are volatile and evaporate over time and exit the booth through the air exhaust system. The organic resins that make up the bulk of the paint coating are insoluble in water and tend to stay tacky if not treated with some additional material introduced to the water (15,16). If left untreated, the tacky solids can plug recirculation pipes and pumps and adhere to wetted surfaces of the booth. Other paint additives, such as wetting agents, pigments, and heavy metals (e.g., zinc and chromium salts) may be soluble in water. These constituents can be made partly insoluble and removed by adjusting the chemistry of the water.

Water-based paints present two problems with regard to water use. First, these paints disperse in water rather than agglomerate like solvent-based paints. This makes the maintenance of paint booth waters more difficult (15,16). Second, water is used to clean spraying equipment when water-based paints are applied, which may generate wastewater. A typical equipment-cleaning procedure is to flush with water, then solvent, then water (18).

Paint Booth Maintenance Requirements. Water-wash paint booths are periodically shut down for maintenance, which usually requires that the water in the booth be removed. Various conditions can exist that may create a need to discharge the water, including odor, bacterial growth, foaming, TDS buildup, and the presence of corrosion and scale constituents.

Booth maintenance typically involves incidental repairs and cleaning the booth surfaces and piping system. Often this is performed according to a maintenance schedule, but periodic repairs may also necessitate an unplanned shut-down and clean-out. A common clean-out procedure is to remove the accumulated paint solids from the water, transfer the water to a

holding tank, and return the water after the maintenance has been performed. Alternate methods are draining the booth water to a sewer or wastewater treatment system or having it hauled to a disposal site. Systems with accumulated paint solids on the wetted surfaces of the booth and in the piping system can be cleaned by circulating an alkaline cleaner or other chemical for dissolving paint. Since the amount of water discharged from water-wash paint booths is a function of the system's maintenance requirements, newer systems that require less maintenance will discharge less water. Therefore, one pollution prevention option for water-wash paint booths is to install new systems or upgrade existing systems to limit maintenance requirements.

15.5.3 Guidance for PNF Selection

The following tables presents PNF data (summarized from Table 15-1) from the MP&M surveys for spray and immersion painting operations, respectively. Data are in gallons of wastewater (i.e., discharged paint booth waters) per square foot of surface area painted.

PNFs for Spray Painting Operations

Minimum PNF	10th Percentile	25th Percentile	Median PNF	75th Percentile	90th Percentile	Maximum PNF	Mean PNF
0.0001	0.002	0.02	0.04	0.04	0.10	1.5	0.08

Source: MP&M Detailed Surveys.

PNFs for Immersion Painting Operations

Minimum PNF	10th Percentile	25th Percentile	Median PNF	75th Percentile	90th Percentile	Maximum PNF	Mean PNF
0.00004	0.00006	0.0005	0.02	0.02	0.19	55	4.6

Source: MP&M Detailed Surveys.

As shown in these tables, the PNFs for painting operations range over several orders of magnitude. The MP&M survey data do not include information on the exact types of pollution prevention and water conservation practices in place at the MP&M sites; therefore, the PNFs listed in this table cannot be directly linked to these practices. Based on data gathered during site visits and from information in technical literature, the Agency believes that the wide range of PNFs indicates the degree to which the sites practice pollution prevention and water conservation (e.g., sites with paint booth water recycling practices in place versus sites without these practices in place).

Based on the available data, the Agency believes that most sites can approach zero discharge of painting booth wastewaters if they implement recycling. For sites that have not implemented recycling of paint booth water, permit writers and control authorities can use the PNF data in the tables above to estimate flow rates for developing mass-based limitations.

15.6 Flow Guidance for Cleaning Operations

Cleaning operations include aqueous degreasing, acid treatment, alkaline treatment, and electrolytic cleaning. Depending on the chemicals, equipment, and procedures used, these processes are commonly referred to as immersion, spray, or electrolytic alkaline cleaning; immersion, spray, or electrolytic acid cleaning or pickling; ultrasonic cleaning; and emulsion cleaning and parts washing.

This section addresses flow guidance for cleaning solutions or baths. Cleaning solutions become contaminated during use and the constituents of the bath are depleted. When the performance of the baths is reduced, the baths are discharged to treatment or contract hauled for off-site treatment and disposal. Rinse waters are also generated from cleaning operations; flow guidance aspects of rinsing are discussed in Section 15.2.

Section 15.6.1 provides background information to identify pollution prevention and water conservation practices applicable to cleaning operations and evaluation criteria to assess if a particular site has properly implemented these practices. Section 15.6.2 shows the influences on flow rates from cleaning operations. Section 15.6.3 presents guidance for PNF selection.

15.6.1 Identification of Sites With Pollution Prevention and Water Conservation Practices

This subsection provides background information and guidance that can be used by the permit writer or control authority can use to determine if a site has implemented pollution prevention and water conservation practices for their cleaning operations. If the site has implemented pollution prevention and water conservation practices, the permit writer or control authority can use the concentration-based limitations to ensure compliance. If the site has not implemented pollution prevention and water conservation practices, the permit writer or control authority can use the information in this subsection to estimate flows for developing mass-based limitations.

Many MP&M sites implement pollution prevention and water conservation methods and technologies that result in low cleaning wastewater discharge rates, and in some cases, eliminate the discharge of cleaning solutions. Pollution prevention and water conservation practices are applicable to all cleaning operations; however, process-related factors and site-specific conditions may restrict the utility of certain methods. This subsection identifies pollution prevention and water conservation practices and technologies applicable to cleaning operations and provides guidance on how to evaluate a site's water use practices.

Wastewater Generation From Cleaning Operations

MP&M sites commonly perform cleaning as a stand-alone operation or in combination with other MP&M unit operations such as anodizing, electroplating, conversion

coating, and painting. Cleaning removes surface contaminants that affect the appearance of parts or the ability to further process the parts. Various types of acidic and alkaline solutions are used for cleaning.

Alkaline cleaners are usually impacted by organic soils such as oil and grease. The effectiveness of most alkaline cleaners is reduced when the oil concentration of the bath is in the range of 1 to 5 g/L or more. Oil and grease enter the alkaline cleaning bath on the parts being processed. The rate of oil buildup depends on the production rate (measured in square feet per day) and the quantity and characteristics of the contamination on the parts. Acid treatment solutions and, to a lesser extent, alkaline treatment solutions accumulate dissolved metals from corrosion of the base metals being processed. The dissolved metal reduces the strength of the cleaning bath. As dissolved metal increases, additional acid or alkaline solution is added; however, at certain metal concentrations, the bath is no longer usable. The tolerable concentration of dissolved metals depends mostly on the type of acid or alkaline solution and the function of the bath. The buildup rate of dissolved metal depends primarily on the production rate, type and concentration of acid or alkaline solution, type of base metal, duration of cleaning cycle, and bath temperature.

Pollution Prevention and Water Conservation Practices for Cleaning Operations

The Agency identified three categories of pollution prevention and water conservation practices that can be implemented to reduce or eliminate wastewater discharges from cleaning operations: housekeeping and maintenance; oil and suspended solids removal; and dissolved solids removal. These are discussed in this subsection and summarized in Table 15-9.

Housekeeping and Maintenance. Sites can implement various housekeeping and maintenance practices to reduce the quantity of cleaning solution discharge. Several of these practices are discussed below.

Solution Testing. The chemical make-up of cleaning solutions changes over time due to evaporative losses, water additions, cleaning chemical drag-out, chemical reactions, and drag-in of impurities. Because of these factors, cleaning baths lose strength, performance declines, and solutions require disposal. Many sites operate cleaning baths on a three-step schedule: formulate, use, and discard. This procedure can be expensive and inefficient from a production standpoint, and creates large volumes of waste. For this reason, sites should frequently test the strength of the cleaning solution and appropriate chemical additions needed to continue using the solution. By implementing testing and record keeping, sites can reduce the disposal frequency of cleaning baths.

Most alkaline cleaning solutions are proprietary formulations, and the vendors of these solutions provide test methods for determining the condition of a bath. Also, commercial test kits are available that include generic test methods. For example, the strength of an alkaline cleaning solution can be tested using acid-base titration, which measures alkalinity. Also, there

is a dual test method that indirectly measures the level of contamination in the cleaner. This process consists of titrating a measured sample of cleaner (e.g., 5 ml) and then adding a color indicator (phenolphthalein or methyl orange) with an acid of precise concentration (e.g., 1N solution of sulfuric acid). Phenolphthalein is used as the indicator to measure free alkalinity and methyl orange is used to measure total alkalinity. By performing both tests, the ratio of total alkalinity to free alkalinity can be calculated. A ratio close to 1 indicates that the cleaner is relatively free of contamination, while a higher ratio indicates that contamination exists. This ratio is sometimes used to determine if a cleaning solution should be discharged. For example, a common guideline used is that the solution is discarded when the ratio exceeds 2.0. The total alkalinity/free alkalinity test method does not work for all cleaners. Because of additives used, some alkaline cleaners do not have any free alkalinity. In such cases, it is necessary to perform more elaborate tests to accurately determine the contaminant concentration (e.g., oil and grease measurement).

Similar test methods exist for acid cleaners. The most common parameters that are included in acid cleaner test programs are acid concentration and dissolved metal concentration. The concentration of sulfuric acid or hydrochloric acid in pickling solutions is usually measured by titrating a sample of the solution with sodium carbonate and using a methyl orange indicator. Iron and other dissolved metals can also be measured by titration or by using laboratory analytical equipment such as an atomic adsorption spectrophotometer.

Recordkeeping. Recordkeeping is essential to maintaining all metal processing solutions, including acid and alkaline cleaners. By maintaining accurate records, a site can identify trends in solution use and focus on extending the lives of those that are frequently discarded. Important records to keep are occurrences of chemical additions and solution dumps, production throughput, and analytical data.

Miscellaneous Housekeeping and Maintenance. To obtain consistently good cleaning results and reduce their solution discharge, sites should implement a regular schedule of housekeeping and maintenance. Tasks should include: checking the accuracy of temperature controls; removing sludge buildup from tanks, heating coils, and temperature regulators; retrieving parts, racks, and other foreign materials dropped into the tanks; and checking the integrity of tanks and tank liners.

Oil and Suspended Solids Removal. Cleaning baths accumulate oil and suspended solids during use. These contaminants eventually reach a concentration that interferes with the effectiveness of the cleaning process, despite the fact that most bath constituents remain usable. Also, contaminated cleaning baths may carry over contaminants to subsequent process solutions. As a result, cleaning baths are often discarded when they reach a certain concentration of contaminants. There are several technologies used to remove oil and suspended solids from cleaning solutions, thereby extending the useful life span of the solutions. These technologies are primarily applicable to alkaline cleaning baths, and are discussed below.

Free/Floating Oil Separation Devices. Separation devices for oil/water mixtures use the difference in specific gravity between oils and water to remove free or floating oil from wastewater. Common separation devices for cleaning solutions include skimming devices (disks, belts, and rotating drum oil skimmers), and coalescers. These devices are not suited for emulsified oil removal, which requires chemical treatment or membrane filtration.

Skimming is a simple method for separating floating oil from cleaning solutions. Skimming devices are typically mounted onto the side of a tank and operate on a continuous basis. The disk skimmer is a vertically rotating disk (typically 12 to 24 inches in diameter) that is partially submerged into the liquid of a tank (typically 4 to 12 inches below the surface). The disk continuously revolves between spring-loaded wiper blades that are located above the surface. The adhesive characteristics of the floating oil cause it to adhere to the disk. As the disk surface passes through the wiper blades, the oil is removed and diverted to a run-off spout for collection. Maximum skimming rates typically range from 2 to 10 gallons per hour of oil. Belt and drum skimmers operate similarly, with either a continuous belt or drum rotating partially submerged in a tank. As the surface of the belt or drum emerges from the liquid, the oil that adheres to its surface is scraped (drum) or squeezed off (belt) and diverted to a collection vessel.

Coalescers separate liquids with specific gravity differences of 0.09 and greater. Coalescers are typically tanks containing a coalescing media that accelerates phase separation (20). A suction skimmer removes cleaning solution and oil from the process tank and pumps it to the coalescer. The media in the coalescers is a material such as polypropylene, ceramic, or glass that attracts oil in preference to water (i.e., oleophilic). The oil/cleaner mixture passes through the unit and the oil adheres to the coalescing media. The oil forms droplets that conglomerate and rise to the surface of the tank, where the oil is removed by a skimming device or weir. According to Stoke's Law, the rise/fall velocity of a dispersed-phase droplet is exponentially increased with the droplet size. Therefore, the coalescing media separates the phases more rapidly than a common gravity settling device.

Media Filtration Methods. Filtration removes suspended solids from cleaning solutions. Common types of filters include cartridge filters, precoat diatomaceous earth filters, and sand or multimedia filters. Cartridge filters are available with either in-tank or external configurations; the in-tank filters typically are used for small tanks and the external filters for larger tanks. Most cartridges are disposable; however, washable and reusable filters are available, which further reduce waste generation. Precoat, sand, and multimedia filters are used mostly for large tank applications. The type of filter media used is based on the chemical composition of the bath. All filtration systems are sized based on solids loading and the required flow rate. Typical flow rates for cleaning solution applications are two to three bath turnovers per hour.

Membrane Filtration. Microfiltration and ultrafiltration are membrane-based technologies used primarily to remove emulsified oil and other colloids from cleaning solutions. The solution entering a microfiltration or ultrafiltration unit is typically filtered conventionally to remove large particulates. Various devices then trap or skim floating oils and allow heavier

solids to settle. The solution is pumped into the membrane compartment, where the membrane traps remaining oil and grease while water, solvent and other cleaning bath constituents pass through. The fluid flows parallel to the membrane with enough velocity to remove the reject from the membrane surface. Ceramic membranes are available in various pore sizes ranging from several hundred angstroms to over 0.2 microns. The appropriate pore size is determined by the specific cleaner to be filtered. The capacity of a unit is based on the total area and flux rate of the membrane. Commercially available units range in capacity from less than 260 to more than 1,300 gallons per day.

Dissolved Metals Removal. Metals become dissolved in acid and alkaline cleaning solutions as a result of corrosion of the base metal. The dissolved metal forms salts or other compounds that reduce the strength of the cleaning bath. Technologies used to remove dissolved metals include acid sorption, diffusion dialysis, and membrane electrolysis, discussed below.

Acid Sorption. Acid sorption is an acid purification technology that is applicable to various acid treatment solutions, as well as other acidic baths (e.g., anodizing baths). The acid sorption unit resembles an ion-exchange column. The column contains a bed of alkaline anion exchange resin that separates the acid from the metal ions.

First, spent acid is pumped upward through the resin; the acid is absorbed by the resin while the metal ions pass through it. The resulting metal-rich, mildly acidic solution is collected at the top of the bed. Water is then pumped downward through the bed and desorbs the acid from the resin. The purified acid solution is collected at the bottom of the bed. This technology can recover approximately 80% of the free acid remaining in a spent acid treatment solution. Purification can be performed in a batch mode, but is most effective in a continuous flow mode (usually expressed in terms of the mass of metal removed from the acid solution per unit time). Equipment capacity ranges from 100 grams/hour to several thousand grams/hour. Units are sized to remove metal near or above the rate at which the metal is being introduced. Typically, a target level of metal concentration is determined and the unit is sized to maintain that level.

Diffusion Dialysis. Diffusion dialysis is a membrane process that separates metal contaminants from the acid solution using an acid concentration gradient between solution compartments. Anion exchange membranes are used to create the compartments. The membranes are usually assembled in a membrane stack, like that used with electrodialysis. The contaminated acid passes through one set of compartments and deionized water through the adjacent compartments. Acid is diffused across the membrane into the deionized water whereas metals are blocked due to their charge and the selectivity of the membrane. Unlike electrodialysis, no electrical potential is used. The acid diffuses because of the difference in acid concentration on either side of the membrane (i.e., material in high concentration moves to an area of low concentration).

Membrane Electrolysis. Membrane electrolysis is a bath maintenance technology that lowers or maintains the concentration of metallic impurities in cleaning solutions. This technology is also applicable to other metal-bearing solutions (e.g., electroplating, anodizing, and stripping solutions). This technology uses an ion-exchange membrane(s) and an electrical potential applied across the membrane(s). The membrane is ion-permeable and selective, permitting ions of a given electrical charge to pass through. Cation membranes allow only cations, (e.g., copper, nickel, aluminum) to pass from one electrolyte to another, while anion membranes allow only anions (e.g., sulfates, chromates, chlorides, cyanide) to pass through. Bath maintenance units can be configured with cation or anion membranes or both.

A typical application of membrane electrolysis is maintenance of an acid cleaning solution. The cleaning solution is placed in an anode compartment that is separated from a second electrolyte by a cation membrane. The solution in the cathode compartment (i.e., catholyte) is typically a dilute acidic or alkaline solution. When an electrical potential is applied, the dissolved metals in the cleaning solution migrate through the cation membrane, into the catholyte. The catholyte is periodically discarded when it becomes saturated with metals.

Evaluating Cleaning Solution Use at a Site

To identify sites with good solution use practices in place for cleaning operations, the permit writer or control authority should focus on the categories of these practices discussed above. Specifically, sites should meet both of the following criteria for the majority of cleaning operations on site:

- (1) The site should use practices to monitor the chemical condition of cleaning solutions and make additions/corrections, as needed; and
- (2) The site should use some type of practice or technology to extend the life of the cleaning solution, including the prevention of contamination and the removal of contaminants.

Table 15-9 presents examples of practices and technologies that sites can implement to satisfy these criteria.

15.6.2 Influences on Flow Rates

Available data show that wastewater discharge rates from cleaning operations are a function of production when measured in terms of the surface area of parts processed (see Table 15-1). Wastewater discharge rates are also affected by other factors that cause PNFs to vary from site to site. Some sites are able to operate without a wastewater discharge, while other sites have a wide range of PNFs. The most important of these factors are the condition of the surfaces being cleaned, cleaning requirements, type of cleaning process used, and the methods used for maintaining the cleaning solution in usable condition. Sites can control this last factor by implementing the proper pollution prevention and water conservation practices and

technologies, as discussed previously. The other factors are, to a degree, beyond control of the site and will affect the minimum PNF achievable by a site. The affects of these factors on PNF are discussed below.

Condition of the Surfaces Being Cleaned. The condition of the parts being cleaned varies widely, both in terms of the types and quantities of contaminants present and the quantity of oil. For example, some parts may have been wiped clean and have only a light deposit of metal-working fluids, while other parts may be heavily coated. Since metal-working fluids (oils) present on the parts are removed during the cleaning process (aqueous degreasing), the rate of oil that is entering into the cleaning solution per square foot of part cleaned will vary. The type of oil entering the cleaning solution will also affect the cleaning fluid's life-span.

Cleaning Requirements. Some processes, such as electroplating, require a high degree of cleanliness while others, such as phosphate conversion coating, may have less stringent requirements. The cleaning requirements will therefore vary within a site, as well as from site to site, as will the type of cleaning process selected.

Some cleaning processes are more amenable to pollution prevention practices than others, based on the purpose of the cleaning process. For example, many electroplating processes require etching of the surface of the part to enhance adhesion of the electroplated metal deposit. Surface etching introduces dissolved metal into the cleaning solution and will reduce its life-span.

Type of Cleaning Process and Equipment. The life-span of cleaning solutions depends on the type of cleaning process (i.e., process chemistry and cleaning equipment). Numerous factors affect the selection of a cleaning process, including: type and characteristics of contaminants to be removed; type and condition of base metal; size and configuration of parts; degree of cleanliness required; processing capabilities at the site; subsequent operations to be performed; and financial considerations.

The factors that most affect the selection of process chemistry and equipment are the type of contaminants present on the parts, type of base metal, and the subsequent finishing operation, which in turn dictates the cleaning requirements. Contaminants present on parts can be divided into organic and inorganic contaminants. Examples of organic contaminants are machining fluids, miscellaneous oils, waxes, and buffing compounds, which are typically removed by solvents, detergents, and alkaline solutions. Examples of inorganic contaminants are scale, smut, and grinding residue, and are typically removed by acidic solutions. Various methods are used to apply the cleaning solution. For example, solutions can be applied by spraying or immersing, and can be applied electrolytically (including both anodic and cathodic cleaning). Application method is primarily based on the concentration and condition of the contaminant and the configuration of the parts.

The base material of the parts is also a consideration in selecting a cleaning process. Some base materials are chemically or physically altered by certain cleaning steps

because of oxidation, etching, activation, and hydrogen embrittlement. Such changes may be either desirable or damaging. The base material is also important in considering the operating conditions of the cleaning process (e.g., concentration, temperature, current). Further, the base material contaminates the cleaning solution (e.g., etching during acid treatment), and therefore affects the life span of the solution.

15.6.3 Guidance for PNF Selection

The following table presents PNF data (summarized from Table 15-1) from the MP&M surveys for cleaning operations. Data are in gallons of solution discharged per square foot of surface area processed.

PNFs for Cleaning Operations

Unit Operation	Minimum PNF	10th Percentile	25th Percentile	Median PNF	75th Percentile	90th Percentile	Maximum PNF	Mean PNF
Aqueous Degreasing	0.0001	0.003	0.009	0.04	0.45	3.8	125	2.3
Acid Treatment	0.000001	0.001	0.004	0.009	0.03	0.2	140	0.43
Alkaline Treatment	0.00002	0.002	0.01	0.01	0.02	0.24	141	1.1
Electrolytic Cleaning	0.00001	0.0005	0.003	0.01	0.08	0.70	85	2.4

Source: MP&M Detailed Surveys.

As shown in this table, the PNFs for cleaning operations range over several orders of magnitude. The MP&M survey data do not include exact information on the types of pollution prevention and water conservation practices in place at the MP&M sites; therefore, the PNFs listed in this table cannot be directly linked to these practices. Based on the data gathered during site visits and from technical literature, the Agency believes that the wide range of PNFs indicates of the variety of water use practices in place at MP&M sites (e.g., sites with cleaning solution maintenance and recycling practices in place versus sites without these practices in place).

Based on the available data and information, the Agency believes that most sites can reduce their flow rates from cleaning operations by implementing pollution prevention and water conservation practices. Site-specific conditions may limit the ability of certain sites to reduce the flow rates.

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Table 15-1 (a)

Descriptive Statistics of MP&M Survey Data for Unit Operations with Square Feet as the Production-Normalizing Parameter

Unit Operation	Total Occurrences	Number of PNF Calculations	Minimum PNF (gal/ft ²)	10th PNF Percentile (gal/ft ²)	25th PNF Percentile (gal/ft ²)	Median PNF (gal/ft ²)	75th PNF Percentile (gal/ft ²)	90th PNF Percentile (gal/ft ²)	Maximum PNF (gal/ft ²)	Mean PNF (gal/ft ²)
Abrasive Blasting	91	28	0.0003	0.0008	0.003	0.026	1.04	1.6	3.9	0.59
Abrasive Blasting Rinse	61	43	0.009	0.26	0.69	1.3	2.4	5.4	40.3	3.1
Acid Treatment with Chromium	61	47	0.00004	0.001	0.008	0.009	0.04	0.09	2.1	0.08
Acid Treatment with Chromium Rinse	50	48	0.002	0.12	1.0	1.3	6.7	41.7	2,686	77
Acid Treatment without Chromium	1,724	1,569	0.000001	0.001	0.004	0.009	0.03	0.20	140	0.43
Acid Treatment without Chromium Rinse	1,422	1,406	0.0001	0.12	0.46	1.3	3.8	19.9	2,631	16.1
Adhesive Bonding	4	4	0.002	0.008	0.02	0.03	0.26	0.65	0.91	0.24
Adhesive Bonding Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Alkaline Cleaning for Oil Removal	567	534	0.00002	0.002	0.013	0.01	0.023	0.24	141	1.1
Alkaline Cleaning for Oil Removal Rinse	407	401	0.0003	0.02	0.16	0.70	1.7	11.8	472	8.3
Alkaline Treatment with Cyanide	23	17	0.002	0.01	0.01	0.01	0.07	1.2	9.0	0.72
Alkaline Treatment with Cyanide Rinse	16	16	0.4	0.4	0.74	2.9	24.2	85.7	153	25.6
Anodizing with Chromium	21	17	0.001	0.006	0.01	0.01	0.01	0.03	0.20	0.023
Anodizing with Chromium Rinse	19	19	0.04	1.1	3.9	3.9	4.3	9.0	20.9	5.0
Anodizing without Chromium	81	60	0.0002	0.004	0.01	0.01	0.01	0.04	1.44	0.06
Anodizing without Chromium Rinse	72	71	0.017	0.27	1.2	3.9	5.0	16.7	938	19.1
Aqueous Degreasing	175	110	0.0001	0.003	0.009	0.04	0.45	3.8	125	2.3
Aqueous Degreasing Rinse	109	69	0.0006	0.016	0.075	0.4	3.8	15.3	2,945	48.3
Assembly/Disassembly	75	3	0.041	0.07	0.11	0.19	0.22	0.24	0.25	0.16

Table 15-1 (a) (Continued)

Unit Operation	Total Occurrences	Number of PNF Calculations	Minimum PNF (gal/ft ²)	10th PNF Percentile (gal/ft ²)	25th PNF Percentile (gal/ft ²)	Median PNF (gal/ft ²)	75th PNF Percentile (gal/ft ²)	90th PNF Percentile (gal/ft ²)	Maximum PNF (gal/ft ²)	Mean PNF (gal/ft ²)
Assembly/Disassembly Rinse	7	5	0.13	0.31	0.59	0.59	0.59	0.59	0.59	0.50
Barrel Finishing	274	44	0.0006	0.005	0.03	0.48	8.2	72	123	16.3
Barrel Finishing Rinse	103	22	0.002	0.009	0.07	1.6	2.9	5.6	81	5.7
Burnishing	21	5	0.012	0.17	0.4	0.84	2.8	39.9	64.7	13.8
Burnishing Rinse	11	1	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07
Calibration	2	2	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Chemical Conversion Coating without Chromium	459	221	0.0000025	0.0004	0.001	0.006	0.075	0.5	96.8	0.87
Chemical Conversion Coating Without Chromium Rinse	366	242	0.0001	0.04	0.16	0.74	2.7	7.1	648	12.9
Chemical Milling	111	79	0.0009	0.015	0.02	0.06	0.11	0.40	11.4	0.3
Chemical Milling Rinse	103	90	0.002	0.18	0.5	1.2	3.0	11.4	64.5	4.3
Chromate Conversion Coating	386	120	0.0000007	0.00006	0.0005	0.008	0.039	1.0	47.9	0.9
Chromate Conversion Coating Rinse	229	135	0.0028	0.016	0.13	0.60	4.3	26.2	2,000	37.2
Corrosion Preventive Coating	178	71	0.00003	0.0009	0.003	0.01	0.052	0.69	42.3	1.8
Corrosion Preventive Coating Rinse	73	61	0.0002	0.15	0.34	1.2	2.0	6.0	833	15.9
Electroless Plating	123	98	0.0002	0.001	0.003	0.02	0.09	0.8	5.9	0.34
Electroless Plating Rinse	116	103	0.005	0.17	0.64	2.2	7.3	26.1	374	17.1
Electrolytic Cleaning	146	137	0.00001	0.0005	0.003	0.013	0.08	0.70	85.7	2.4
Electrolytic Cleaning Rinse	133	132	0.0001	0.02	0.2	0.8	5.5	22.2	446	14.0
Electroplating with Chromium	73	39	0.0007	0.006	0.02	0.02	0.03	2.7	11.4	0.88
Electroplating with Chromium Rinse	77	71	0.006	0.2	1.0	2.6	13.1	38.8	943	26.7
Electroplating with Cyanide	261	121	0.00004	0.002	0.007	0.02	0.16	0.95	90.6	1.4
Electroplating with Cyanide Rinse	235	219	0.0003	0.04	0.57	2.6	16.6	80.0	1,828	38.4
Electroplating without Chromium or Cyanide	522	260	0.00001	0.0004	0.005	0.02	0.075	0.5	23.5	0.45

Table 15-1 (a) (Continued)

Unit Operation	Total Occurrences	Number of PNF Calculations	Minimum PNF (gal/ft ²)	10th PNF Percentile (gal/ft ²)	25th PNF Percentile (gal/ft ²)	Median PNF (gal/ft ²)	75th PNF Percentile (gal/ft ²)	90th PNF Percentile (gal/ft ²)	Maximum PNF (gal/ft ²)	Mean PNF (gal/ft ²)
Electroplating without Chromium or Cyanide Rinse	496	490	0.0003	0.12	0.60	2.6	10	42.1	9,333	54.7
Electropolishing	18	17	0.0002	0.01	0.01	0.01	0.03	3.7	7.7	0.92
Electropolishing Rinse	14	14	0.01	0.04	0.8	3.5	19.9	27.2	187	20.6
Floor Cleaning	388	340	0.00008	0.006	0.008	0.1	0.1	1.3	156	2.0
Floor Cleaning Rinse	75	73	0.0025	0.009	0.06	0.1	0.33	3.4	49	1.6
Flush/Fill Radiators	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Heat Treating Quench	136	76	0.00002	0.02	0.12	0.12	0.12	0.6	13	0.5
Heat Treating Rinse	36	34	0.0001	0.003	0.2	0.7	1.2	4.0	781	30
Hot Dip Coating	2	1	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Hot Dip Coating Rinse	1	1	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Impact Deformation	50	23	0.12	0.12	0.12	0.12	0.12	6.9	6.9	1.3
Impact Deformation Rinse	8	8	0.4	0.6	0.6	0.6	20.9	41	49	13.1
Laundering	1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mechanical Plating	4	4	0.013	0.021	0.034	0.097	0.185	0.24	0.282	0.122
Mechanical Plating Rinse	4	4	0.44	0.55	0.71	1.0	1.34	1.58	1.73	1.0
Metal Spray (Incl. Water Curtains)	10	4	0.03	0.30	0.69	0.91	0.91	0.91	0.91	0.69
Painting Spray (Incl. Water Curtains)	170	130	0.000062	0.002	0.02	0.04	0.04	0.10	1.52	0.08
Painting Spray Rinse	16	16	0.00025	0.01	0.04	0.12	0.80	1.3	2.5	0.49
Painting Immersion	23	12	0.00004	0.00007	0.0005	0.02	0.02	0.19	54.6	4.6
Painting Immersion Rinse	18	16	0.002	0.008	0.022	0.06	0.43	12.3	28.8	3.4
Phosphor Deposition	1	1	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
Phosphor Deposition Rinse	1	1	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
Photo Imaging Developing	125	114	0.0007	0.006	0.034	0.096	0.33	0.80	45.15	0.83
Photo Imaging Developing Rinse	113	112	0.046	0.26	1.30	1.74	2.95	7.95	65.97	4.14
Photo Resist Applications	6	4	0.001	0.002	0.003	0.012	0.25	0.66	0.93	0.24
Photo Resist Applications Rinse	2	2	0.032	2.4	5.9	11.8	17.8	21.3	23.7	11.8

Table 15-1 (a) (Continued)

Unit Operation	Total Occurrences	Number of PNF Calculations	Minimum PNF (gal/ft ²)	10th PNF Percentile (gal/ft ²)	25th PNF Percentile (gal/ft ²)	Median PNF (gal/ft ²)	75th PNF Percentile (gal/ft ²)	90th PNF Percentile (gal/ft ²)	Maximum PNF (gal/ft ²)	Mean PNF (gal/ft ²)
Physical Vapor Deposition	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Physical Vapor Deposition Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Plastic Wire Extrusion	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Plastic Wire Extrusion Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Polishing	60	33	0.0002	0.22	0.48	0.48	0.48	3.92	62	3.4
Polishing Rinse	27	24	0.0002	0.1	1.28	4.47	6.2	19.5	60	9.1
Pressure Deformation	55	37	0.105	0.12	0.12	0.12	0.12	0.12	6.9	0.48
Pressure Deformation Rinse	11	11	0.14	0.68	0.68	0.68	21.2	37.4	50.2	12.4
Salt Bath Descaling	3	2	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Salt Bath Descaling Rinse	5	5	0.68	0.68	0.68	0.68	2	12.8	20	4.8
Shot Tower-Lead Shot Manufacturing	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Shot Tower-Lead Shot Manufacturing Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Soldering/Brazing	61	15	0.002	0.011	0.16	0.91	0.95	13.4	26.4	3.8
Soldering/Brazing Rinse	45	39	0.26	0.91	0.91	0.91	1.7	15.3	454	17.1
Solder Flux Cleaning	45	11	0.001	0.002	0.007	0.018	0.13	1.7	7.7	0.88
Solder Flux Cleaning Rinse	40	40	0.012	0.18	0.49	1.60	4.9	14.6	34	4.8
Solder Fusing	26	10	0.0005	0.004	0.007	0.01	0.04	0.51	3.7	0.40
Solder Fusing Rinse	23	23	0.07	0.32	0.50	1.2	5.8	17.8	60	6.7
Solvent Degreasing	47	9	0.013	0.013	0.013	0.013	0.028	1.17	5.2	0.013
Solvent Degreasing Rinse	26	26	0.17	0.72	0.80	0.80	2.4	30	1713	74.1
Sputtering	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Sputtering Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Steam Cleaning	2	2	0.013	12.5	31.26	62.5	93.8	112.5	125	62.5
Stripping Paint	162	140	0.0005	0.005	0.02	0.03	0.05	0.22	1.7	0.09
Stripping Paint Rinse	160	156	0.02	0.16	0.51	1.30	3.5	11.8	113	5.7
Stripping Metallic Coating	252	217	0.0002	0.004	0.014	0.03	0.09	0.42	61	0.72

Table 15-1 (a) (Continued)

Unit Operation	Total Occurrences	Number of PNF Calculations	Minimum PNF (gal/ft ²)	10th PNF Percentile (gal/ft ²)	25th PNF Percentile (gal/ft ²)	Median PNF (gal/ft ²)	75th PNF Percentile (gal/ft ²)	90th PNF Percentile (gal/ft ²)	Maximum PNF (gal/ft ²)	Mean PNF (gal/ft ²)
Stripping Metallic Coating Rinse	214	209	0.003	0.22	0.65	2.1	9.6	40	5954	67
Testing	256	231	0.0004	0.59	0.59	0.59	0.59	0.75	79.5	2.2
Testing Rinse	69	69	0.01	0.15	0.59	0.59	0.95	6.8	1197	22.5
Thermal Cutting	22	8	0.12	0.18	0.20	0.64	0.91	0.91	0.90	0.57
Thermal Infusion	1	1	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Thermal Infusion Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Ultrasonic Machining	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Ultrasonic Machining Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Vacuum Impregnation	4	1	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Vacuum Impregnation Rinse	2	2	1.9	1.9	14	26	38.3	45.5	50.4	26
Vacuum Plating	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Vacuum Plating Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Washing Finished Products	299	250	0.00002	0.007	0.013	0.01	0.20	3.8	941	6.4
Washing Finished Products Rinse	123	119	0.002	0.02	0.08	0.70	0.83	3.0	78.9	2.6
Water Shedder	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Water Shedder Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Welding	95	26	0.00004	0.003	0.28	0.90	0.91	3.71	12.5	1.6
Welding Rinse	6	6	0.01	0.16	0.32	0.62	11	22.5	30.7	7.8

NA - Not applicable.

Table 15-1 (b)

Descriptive Statistics of MP&M Survey Data for Unit Operations with Pounds of Metal Removed as the Production-Normalizing Parameter

Unit Operation	Total Occurrences	Number of PNF Calculations	Minimum PNF (gal/lb met rem)	10th Percentile (gal/lb met rem)	25th Percentile (gal/lb met rem)	Median PNF (gal/lb met rem)	75th Percentile (gal/lb met rem)	90th Percentile (gal/lb met rem)	Maximum PNF (gal/lb met rem)	Mean PNF (gal/lb met rem)
Abrasive Jet Machining	6	6	0.0009	0.003	0.009	0.02	0.02	0.04	0.06	0.02
Abrasive Jet Machining Rinse	0	0	NA	NA	NA	NA	NA	NA	NA	NA
Electrical Discharge Machining	34	12	0.04	0.16	0.65	1.7	4.4	14.9	450	40.4
Electrical Discharge Machining Rinse	3	2	1	1.08	1.2	1.4	1.6	1.7	1.8	1.4
Grinding	511	427	0.0003	0.033	0.093	0.12	0.64	5.6	36000	247
Grinding Rinse	47	40	0.0007	0.2	20.7	318	1551	6370	291800	466
Machining	1369	1143	0.0003	0.11	0.05	0.12	0.18	1.7	376	1.6
Machining Rinse	21	19	0.001	0.02	0.09	0.7	319	338	376	109
Plasma Arc Machining	37	25	0.35	2	2	2	2	2.6	22	2.9

NA - Not applicable.

Table 15-2

Water Conservation Methods for Surface Treatment Rinses

Practice	Alkaline Clean	Acid Clean	Hexavalent Chromium	Trivalent Chromium	Cadmium Zinc Cyanide	Cadmium Zinc Non-Cyanide	Acid Copper	Copper Cyanide	Watts, Woods, Other Nickels	Electro-less Nickel	Silver Cyanide	Gold Cyanide	Lead, Lead-Tin	Tin	Chromate	Phosphate	Chromic-Acid Anodize	Sulfuric Anodize
Drag-out Reduction and Recovery																		
Fog or spray rinsing over tank (110° F or higher)	T	T	T	T				T	T	T				T ^a		T	T	
Controlled slow withdrawal	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Addition of wetting agent (when compatible)			T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Positioning work piece	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Long drip time	T	T	T	T	T	T	T	T			T	T	T	T	T	T	T	T
Drip shield	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Air knife	T	T	T	T	T	T					T	T			T	T		T
Drag-out tank (heated)	T		T	T	T	T	T	T	T	T	T	T	T	T	T	T		
Drag-in/out tank	T		T	T	T	T	T	T	T	T	T	T	T	T	T	T		
Lowest concentration	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Highest temperature	T	T	T	T	T	T		T	T	T	T	T	T	T	T	T	T	T
Rinse Tank Design and Innovative Configuration																		
Countercurrent rinse	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Cascading rinse (cleaning)	T	T																
Spray rinse	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Good tank design ^b	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T

Table 15-2 (Continued)

Practice	Alkaline Clean	Acid Clean	Hexavalent Chromium	Trivalent Chromium	Cadmium Zinc Cyanide	Cadmium Zinc Non-Cyanide	Acid Copper	Copper Cyanide	Watts, Woods, Other Nickels	Electro-less Nickel	Silver Cyanide	Gold Cyanide	Lead, Lead-Tin	Tin	Chrom-ate	Phos-phate	Chromic-Acid Anodize	Sulfuric Anodize
Rinse Water Use Control																		
Flow restrictors	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Timer controls	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Conductivity controls	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Metal Recovery and Rinse Water Reuse Technologies																		
Evaporator ^d	T	T	T	T	T	T	T	T	T	T			T	T	T	T	T	
Ion exchange ^e					T	T	T	T	T	T	T	T	T	T				
Electrolytic Recovery					T	T	T	T	T	T	T	T						
Electrodialysis ^e		T			T	T			T									
Reverse osmosis ^e					T	T	T	T	T				T	T	T			

Source: MP&M Site Visits, MP&M surveys, Technical Literature.

^aAlkaline tin only.^bFor example: Air or other agitation, minimum size, and inlet, outlet location opposite ends.^cOnly common applications of this technology are checked.

Table 15-3

**Definitions of Pollution Prevention
and Water Conservation Practices and Technologies**

Practice or Technology	Definition
Air Knife	Air knives are usually installed over a process tank or drip shield and are designed to remove drag-out by blowing it off the surface of parts and racks. Drag-out is routed back to the process tank. Air knives are more effective with flat parts. Air knives cannot be used to dry surfaces that passivate or stain due to oxidation.
Cascade Rinse	Cascade rinsing is a method of reusing rinse water. Rinse water from one rinsing operation is plumbed to another, less critical one before being discharged to treatment. Some rinse waters acquire chemical properties, such as low pH, that make them desirable for reuse in specific rinse systems. This is generally referred to as reactive rinsing.
Conductivity Controller	<p>Conductivity probes measure the conductivity of water in a rinse tank to regulate the flow of fresh rinse water into the rinse system. Conductivity controllers consist of a controller, a meter with adjustable set points, a probe that is placed in the rinse tank, and a solenoid valve. As parts are rinsed, dissolved solids are added to the water in the rinse tank, raising the conductivity of the water. When conductivity reaches the set point, the solenoid valve is opened to allow make-up water to enter the tank. When the conductivity falls below the set point, the valve is shut to discontinue the make-up water.</p> <p>In theory, conductivity control of rinse flow is a precise method of maintaining optimum rinsing conditions in intermittently used rinse operations. In practice, conductivity controllers work best with deionized rinse water. Incoming water conductivity may vary day to day and season to season, which forces frequent set-point adjustments. Suspended solids and nonionic contaminants (e.g., oil) are not detected by the conductivity probe and can cause inadequate rinsing.</p>
Countercurrent Cascade Rinse	Countercurrent cascade rinsing refers to a series of consecutive rinse tanks that are plumbed to cause water to flow from one tank to another in the direction opposite of the work flow. Countercurrent cascade rinsing is widely used to reduce the discharge rate of rinse water. Fresh water flows into the rinse tank located farthest from the process tank and overflows, in turn, to the rinse tanks closer to the process tank. This technique is termed countercurrent rinsing, because the work piece and the rinse water move in opposite directions. Over time, the first rinse becomes contaminated with drag-out and reaches a stable concentration that is lower than the process solution. The second rinse stabilizes at a lower concentration, which enables less rinse water to be used than if only one rinse tank were in place. The more countercurrent cascade rinse tanks (three-stage, four-stage, etc.), the less water is needed to adequately remove the process solution.

Table 15-3 (Continued)

Practice or Technology	Definition
Drag-in/Drag-out Rinsing	A drag-in/drag-out rinse system may be a single tank or two tanks plumbed together. Parts enter the rinse system before and after processing in the bath. As parts enter the process bath, they drag in process chemicals present in the drag-in/drag-out rinse rather than plain rinse water. This rinsing configuration is an effective recovery method for process baths that have low evaporation rates.
Drag-out Tank	Drag-out tanks are rinse tanks that are initially filled with water and remain stagnant. Parts are rinsed in drag-out tanks directly after exiting the process bath. Gradually, the concentration of process chemicals in the drag-out tank rises. In the most efficient configuration, a drag-out tank is used after a heated process tank that has a moderate to high evaporation rate. Part of the fluid in the drag-out tank is returned to the process tank to replace the evaporative loss. The level of fluid in the drag-out tank is maintained by adding fresh water.
Drip Shields	Drip shields are installed between process tanks and rinse tanks to recover process fluid dripping off racks and barrels that would otherwise fall into rinse tanks or onto the floor. Often, drip shields are an inclined piece of polypropylene or other material that is inert to the process.
Drip Tanks	Drip tanks are similar to drag-out tanks except they are not filled with water. Parts exiting a process bath are held over the drip tank and the process fluid that drips from the parts is collected in the tank. When enough fluid is collected in the drip tank, it is returned to the process tank. Drip tanks are generally considered to be a less effective drag-out recovery practice than using drag-out tanks.
Electrodialysis	<p>Electrodialysis is a membrane technology used to remove impurities from and recover process solutions. With this technology, a direct current is applied across a series of alternating anion and cation exchange membranes to remove dissolved metal salts and other ionic constituents from solutions.</p> <p>An electrodialysis unit consists of a rectifier and a membrane stack. The stack consists of alternating anion- and cation-specific membranes that form compartments. As the feed stream enters the unit, each alternating membrane compartment becomes filled with either diluate or concentrate. When the compartments are filled, a direct current is applied across the membrane. Cations in a diluate compartment traverse one cation-specific membrane in the direction of the cathode, and are trapped in that compartment by the next membrane, which is anion-specific. Anions from the neighboring diluate compartment traverse the anion-specific membrane in the direction of the anode, joining the cations, and are likewise trapped in the concentrate compartment by the next cation-specific membrane. In this way, the feed stream is depleted of ions, and anions and cations are trapped in each concentrate compartment.</p> <p>The feed stream is often from the first rinse tank in a countercurrent series, with a concentration of 5 g/L or more of TDS. The concentrate, with a TDS concentration of 50 g/L or more, and a volume of less than 10% of the feed stream, is returned to the process. The diluate, representing more than 90% of the feed stream at a TDS concentration of typically 1 g/L or less, is recycled as rinse water or discharged to treatment.</p>

Table 15-3 (Continued)

Practice or Technology	Definition
Electrolytic Recovery (Electrowining)	<p>Electrolytic recovery is an electrochemical process used to recover metals from many types of process solutions, such as electroplating rinse waters and baths. Electrolytic recovery removes metal ions from a wastestream by processing the stream in an electrolytic cell, which consists of a closely spaced anode and cathode. Commercial equipment consists of several cells, a transfer pump, and a rectifier. Current is applied across the cell and metal cations are deposited on the cathodes. The wastestream is usually recirculated through the cell from a separate tank, such as a drag-out recovery rinse.</p> <p>Electrolytic recovery is typically applied to solutions containing nickel, copper, precious metals, and cadmium. Chromium and aluminum are poor candidates for electrolytic recovery. Drag-out recovery rinses and ion-exchange regenerant are common solutions that are processed using electrolytic recovery. Some solutions require pH adjustment prior to electrolytic recovery. Acidic, metal-rich, cation regenerant is an excellent candidate stream for electrolytic recovery, and is often electrolytically recovered without adjustment. In some cases, when the target concentration is reached, the wastestream is reused as cation regenerant.</p>
Evaporation	<p>Evaporation is a common chemical recovery technology. There are two basic types of evaporators: atmospheric and vacuum. Atmospheric evaporators, the more prevalent type, are relatively inexpensive to purchase and easy to operate. Vacuum evaporators are mechanically more sophisticated and are more energy efficient. Vacuum evaporators are typically used when evaporation rates greater than 50 to 70 gal/hour are required. Additionally, with vacuum evaporators, evaporated water can be recovered as a condensate and reused on site.</p> <p>A disadvantage of evaporation-based recovery is that all drag-out, including unwanted components, are returned and accumulate in the process bath. For this reason, deionized water is preferred as rinse water to prevent the introduction of water contaminants in the process bath.</p>
Flow Restrictor	<p>Flow restrictors prevent the flow in a pipe from exceeding a predetermined volume. They are commonly installed on a rinse tank's water inlet. These devices contain an elastomer washer that flexes under pressure to maintain a constant water flow regardless of pressure. Flow restrictors can maintain a wide range of flow rates, from less than 0.1 gal/min to more than 10 gal/min.</p> <p>As a stand-alone device, a flow restrictor provides a constant water flow. As such, for intermittent rinsing operations, a flow restrictor does not coordinate the rinse flow with drag-out introduction. Precise control with intermittent operations typically requires a combination of flow restrictors and rinse timers. However, for continuous rinsing (e.g., continuous electroplating machines), flow restrictors may be adequate for good water control.</p>
Fog or Spray Rinse Over Tank	<p>Fog or spray rinsing is performed over a process bath to recover drag-out. Draining over a process bath can be greatly enhanced by spray or fog rinsing, which dilutes and lowers the viscosity of the film of process fluid clinging to the parts. This method of drag-out recovery is only possible if the evaporation rate of the process fluid is moderate to high.</p>

Table 15-3 (Continued)

Practice or Technology	Definition
Good Tank Design	<p>Rinse tanks should be designed to remove the drag-out layer from the part and cause it to rapidly and thoroughly mix with the rinse water. Common elements of good tank design are positioning the inlet and outlet at opposite ends of the tank, using air or other agitation, using a flow distributor, and using the minimum size of tank possible.</p>
Ion Exchange	<p>Ion exchange is a reversible chemical reaction that exchanges ions in a feed stream for ions of like charge on the surface of an ion-exchange resin. Resins are broadly divided into cationic or anionic types. Typical cation resins exchange H^+ for other cations, while anion resins exchange OH^- for other anions.</p> <p>In practice, a feed stream is passed through a vessel, referred to as a column, which holds the resin. The feed stream is typically dilute rinse water. The exchange process proceeds until the capacity of the resin is reached (i.e., an exchange has occurred at all the resin sites). A regenerant solution is then passed through the column. For cation resins, the regenerant is an acid, and the H^+ ions replace the cations captured from the feed stream. For anion resins, the regenerant is a base, and OH^- ions replace the anions captured from the feed stream. The concentration of feed stream ions is much higher in the regenerant than in the feed stream; therefore, the ion-exchange process accomplishes both separation and concentration.</p> <p>Ion exchange is used for water recycling and/or metal recovery. For water recycling, cation and anion columns are placed in series. The feed stream is deionized and the product water is reused for rinsing. Often, closed-loop rinsing is achieved. The regenerant from the cation column typically contains the metal species, which can be recovered in elemental form via recovery. The anion regenerant is typically discharged to wastewater treatment. When metal recovery is the only objective, a single or double cation column unit containing selective resin is used. These resins attract divalent cations while allowing monovalent cations to pass, a process usually referred to as metal scavenging. Water cannot be recycled because contaminants other than the target cations remain in the stream exiting the column.</p>
Long Drip Time	<p>Long drip times over the process tank reduce the volume of drag-out reaching the rinsing system. Automatic lines can be easily programmed to include optimum drip times. On manual lines, racks are commonly hung on bars over process baths and allowed to drip. Barrels can be rotated over the process bath to enhance drainage. Some surfaces cannot tolerate long exposure to air due to oxidation or staining, and would therefore be unsuitable for extended drip times.</p>
Raising Bath Temperature	<p>Bath temperature and viscosity are inversely related. Operating at the highest possible bath temperature lowers viscosity and reduces drag-out. Higher bath temperatures also increase evaporation, which facilitates efficient recovery rinsing.</p>
Lowering Bath Concentration	<p>Operating at the lowest possible concentration reduces the mass of chemicals in a given volume of drag-out. Also, viscosity and concentration are directly related and lower process bath concentration lowers viscosity and reduces drag-out volume. Contaminants and other substances that build in concentration over the life of a process bath should be controlled at a low level, if possible.</p>

Table 15-3 (Continued)

Practice or Technology	Definition
Part Position on Rack	Positioning parts on racks to promote rapid draining includes minimizing the profile of the parts emerging from the bath, tilting and inverting cup-shaped parts, and avoiding placement of parts directly atop one another.
Slow Part Withdrawal	The faster a part is removed from a process bath, the thicker the layer of fluid clinging to the part will be. A slower withdrawal rate reduces the thickness of the fluid layer and reduces drag-out. Generally, this method of drag-out reduction can only be practiced on automatic lines where the withdrawal velocity can be programmed.
Reverse Osmosis	<p>Reverse osmosis is a membrane separation technology used for chemical recovery. The feed stream, usually relatively dilute rinse water or wastewater, is pumped to the surface of the reverse osmosis membrane at pressures of 400 to 1,000 psig. The membrane separates the feed stream into a reject stream and a permeate. The reject stream, containing most of the dissolved solids in the feed stream, is deflected from the membrane while the permeate passes through. Reverse osmosis membranes reject more than 99% of multivalent ions and 90% to 96% of monovalent ions, in addition to organic pollutants and nonionic dissolved solids. The permeate stream is usually of sufficient quality to be recycled as rinse water, despite the small percentage of monovalent ions (commonly potassium, sodium and chloride) that pass through the membrane.</p> <p>A sufficiently concentrated reject stream can be returned directly to the process bath. The reject stream concentration can be increased by recycling the stream through the unit more than once or by increasing the feed pressure. In multiple-stage units containing more than one membrane chamber, the reject stream from the first chamber is routed to the second, and so on. The combined reject streams from multistage units may, in some cases, have high enough concentrations to be returned directly to the bath.</p>
Timer Rinse Controller	<p>Rinse timers are electronic devices that control a solenoid valve. The timer usually consists of a button that, when pressed, opens the valve for a predetermined length of time, usually from 1 to 99 minutes. When the valve is open, make-up water is allowed to flow into a given tank. After the time period has expired, the valve is automatically shut. The timer may be activated either manually by the operator or automatically by the action of racks or hoists.</p> <p>Most rinse systems that are used intermittently benefit from the installation of a rinse timer, as operator error is eliminated. Rinse timers installed in conjunction with flow restrictors can provide precise control when the incoming water pressure may rise and fall. Rinse timers are less effective in continuous or nearly continuous rinse operations (e.g., continuous electroplating machines).</p>
Wetting Agents	Wetting agents or surfactants may be added to some process baths to reduce viscosity and surface tension, thereby significantly reducing drag-out.

Source: MP&M Site Visits, MP&M Surveys, Technical Literature.

Table 15-4**Factors Affecting Drag-Out**

Factor Affecting Drag-Out	Impact on Drag-out	Potential Pollution Prevention and Water Conservation Practices	Restrictions
Bath Concentration	Concentration and drag-out are directly related.	Operate at lowest concentration possible. Remove all contaminants promptly.	Concentration range limited by process.
Bath Temperature	Higher temperatures lower drag-out by lowering viscosity.	Operate at highest possible temperature.	Temperature range limited by process.
Bath Viscosity	High viscosity raises drag-out by increasing the thickness of the fluid layer clinging to the part.	Operate at highest temperature and lowest concentration possible. Add wetting agent.	Concentration and temperature ranges limited by process. Wetting agent must be compatible.
Part Configuration	Cup shapes result in 8-20 times the drag-out volume of flat shapes.	Drain holes can be added to many cup-shaped parts to improve drainage of drag-out.	Functionality of parts may restrict use of drain holes or other changes to part configuration.
Part Orientation	Orientation on rack can be optimized to minimized drag-out.	Keep records of optimal orientations. Train operators.	None.
Withdrawal Rate	Doubling speed of withdrawal results in a fourfold increase in drag-out volume.	Program automatic equipment for slow withdrawal.	Impossible to consistently practice without automation.
Drain Time	Long drain times and barrel rotations greatly reduce drag-out.	Program automatic equipment for long drain times.	Impossible or difficult to consistently practice without automation. Drain time limited by staining or passivation of some coatings.
Rack versus Barrel	Barrels produce greater drag-out than racks.	(See "Rack/Barrel Design)	Part transport device is dictated by part size.
Rack/Barrel Design	Drag-out volume is related to barrel design.	Redesign barrels with largest holes possible.	Barrel design limited by part sizes and configurations.
Rack/Barrel Condition	Loose rack coating cause reservoirs of fluid to be transported with rack.	Maintain a schedule of maintenance and recoating.	None
Operator Awareness	Poor operator awareness greatly increases drag-out or offsets other practices.	Require training programs for operators.	None

Source: MP&M Site Visits, MP&M Surveys, Technical Literature.

Table 15-5**Rinse-water Required for Various Plating Processes Based on Literature Values^a**

Process	Rinse Configuration	TDS Concentration	Target TDS Concentration in Rinse	Part Type	Drag-out Rate	PNF gal/ft ² 100% Control	PNF gal/ft ² 100% Excess
Acid Zinc	Single overflow	166 g/L	Functional: 100-700 mg/L (used 400 mg/L)	Flat	1.3 gal/1,000 ft ²	0.54	1.1
				Contoured	3.5 gal/1,000 ft ²	1.5	2.9
	2-stage countercurrent cascade	166 g/L	Functional: 100-700 mg/L (used 400 mg/L)	Flat	1.3 gal/1,000 ft ²	0.024	0.048
				Contoured	3.5 gal/1,000 ft ²	0.072	0.14
Silver Cyanide	Single overflow	370 g/L	Bright: 5-40 mg/L (used 20 mg/L)	Flat	1.2 gal/1,000 ft ²	22	44
				Contoured	3.2 gal/1,000 ft ²	58	120
	2-stage countercurrent cascade	370 g/L	Bright: 5-40 mg/L (used 20 mg/L)	Flat	1.2 gal/1,000 ft ²	0.16	0.32
				Contoured	3.2 gal/1,000 ft ²	0.43	0.87

Table 15-5 (Continued)

Process	Rinse Configuration	TDS Concentration	Target TDS Concentration in Rinse	Part Type	Drag-out Rate	PNF gal/ft ² 100% Control	PNF gal/ft ² 100% Excess
Copper Cyanide	Single overflow	250 g/L	Functional: 100-700 mg/L (used 400 mg/L)	Flat	0.91 gal/1,000 ft ²	0.57	1.1
				Contoured	3.2 gal/1,000 ft ²	2.0	4.0
	2-stage countercurrent cascade	250 g/L	Functional: 100-700 mg/L (used 400 mg/L)	Flat	0.91 gal/1,000 ft ²	0.023	0.046
				Contoured	3.2 gal/1,000 ft ²	0.081	0.16
Acid Descale	Single Overflow	248 g/L	Clean: 400-1000 mg/L (used 700 mg/L)	Flat	1 gal/1,000 ft ² (estimated)	3.5	7.1
				Contoured	3 gal/1,000 ft ² (estimated)	11	21
	2-stage countercurrent cascade	248 g/L	Clean: 400-1000 mg/L (used 700 mg/L)	Flat	1 gal/1,000 ft ² (estimated)	0.019	0.038
				Contoured	3 gal/1,000 ft ² (estimated)	0.056	0.11

Table 15-5 (Continued)

Process	Rinse Configuration	TDS Concentration	Target TDS Concentration in Rinse	Part Type	Drag-out Rate	PNF gal/ft ² 100% Control	PNF gal/ft ² 100% Excess
Alkaline Clean (Proprietary Chemistry)	Single overflow	90 g/L	Clean: 400-1000 mg/L (used 700 mg/L)	Flat	1 gal/1,000 ft ² (estimated)	0.13	0.26
				Contoured	3 gal/1,000 ft ² (estimated)	0.39	0.77
	2-stage countercurrent cascade	90 g/L	Clean: 400-1000 mg/L (used 700 mg/L)	Flat	1 gal/1,000 ft ² (estimated)	0.011	0.022
				Contoured	3 gal/1,000 ft ² (estimated)	0.033	0.066

^aTDS concentrations are from References 3 and 4, based on bath formulations. Target TDS concentrations are based on criteria presented in Section 3.2.1 (Reference 1). Drag-out rates are from References 1 and 2 unless data were not available, in which case rates were assumed based on technical knowledge of the operations.

Sources: References 1, 3, and 4.

1. Acid zinc formulation:

ZnSO ₄ (7H ₂ O)	240 g/L
NH ₄ Cl	15 g/L
Al ₂ (SO ₄) ₃ (18H ₂ O)	30 g/L
Licorice	1 g/L

2. Equation used to calculate rinse flow and flow per square foot for single overflow rinse:

$$C_e = \left(\frac{D}{QM \% D} \right) C_o$$

$$Q = \frac{\left(\frac{DC_o}{C_e} \right) \& D}{M}$$

Solving for Q:

Where:

D	=	Drag-out per ft ² (gal)	C _e	=	Target concentration of rinse (oz/gal)
C _o	=	Concentration of process bath (oz/gal)	C _r	=	Target concentration of final rinse
(oz/gal)					
M	=	Interval between drag-out events (minutes)	Q	=	Flow (gal/min)

Note: Any interval M can be chosen. Q, when divided by the work rate, ft²/M, yields the gal/ft² in the table and the gal/ft² number remains the same for any M.

3. Equation used to calculate 100% controlled flow and gallons per square foot for countercurrent cascade rinse:

$$Q = \frac{D}{M} \left(\frac{C_o}{C_r} \right)^{1/n}$$

Where n = number of rinse stages

For 50% controlled flow, Q was multiplied by a factor of 2.

With 100% controlled flow, the introduction of drag-out and rinsewater into the rinse tank are perfectly coordinated and, therefore, the rinsewater required to meet the target concentration of the final rinse is equal to Q. With 100% excess flow, the introduction of drag-out and rinsewater are not perfectly coordinated and an excess of 100% of Q (or 2Q) is used to meet the target concentration of the final rinse.

4. Silver cyanide formulation (middle of high-speed bath range):

AgCN	97.5 g/L
KCN	152.5 g/L
K ₂ CO ₃	52.5 g/L
KNO ₃	50 g/L
KOH	17 g/L

5. High-efficiency copper cyanide formulation:

CuCN	75 g/L
KCN	133 g/L
KOH	42 g/L

6. Acid descale formulation:

20% H₂NO₃ (by volume)
1.5% HF (by volume)

All bath formulations and equations are from References 1, 3, and 4.

Table 15-6

**Adjusted Production-Normalized Flow (PNF) Data for Countercurrent
Cascade-Rinses**

Measured PNF (gal/ft ²)	Measured TDS (mg/L)	Adjusted TDS (mg/L) ^a	Adjusted PNF (gal/ft ²) ^b	Part Description
CLEANING RINSES WITH FLOW CONTROL (Includes timed rinses, conductivity sensors, flow restrictors, and manual shut-off)				
0.031	1,600	700	0.047	Doorknob components
0.037	1,800	700	0.059	Doorknob components
0.054	1,700	700	0.084	Doorknob components
0.26	1,300	700	0.36	Doorknob components
0.26	2,000	700	0.44	Doorknob components
0.26	1,100	700	0.33	Doorknob components
0.30	1,100	700	0.37	Doorknob components
0.38	1,100	700	0.48	Doorknob components
0.49	1,400	700	0.69	Doorknob components
0.49	940	700	0.56	Doorknob components
0.62	1,200	700	0.81	Doorknob components
0.62	860	700	0.68	Doorknob components
PLATING AND CONVERSION COATING RINSES WITH FLOW CONTROL (Includes timed rinses, conductivity meters, flow restrictors, and manual shut-off)				
0.017	400	3,900	0.15	Shafts for mobile industrial equipment
0.037	400	4,100	0.350	Shafts for mobile industrial equipment
0.16	400	4,100	1.5	Shafts for mobile industrial equipment
0.83	720	400	0.350	Doorknob Components
1.5	730	400	1.5	Doorknob components

Source: Sampling episode data from two MP&M sites.

^aAdjusted TDS based on rinsing criteria presented in Section 3.1.2 (Reference 1).

^bThe adjusted PNFs account for the fact that the TDS was measured from the discharge of first tank in the countercurrent cascade series. EPA assumes the TDS present in the measured rinse is entirely composed of drag-out and that the rinse water supplied is deionized.

Table 15-7

**Pollution Prevention and Water Conservation Methods Applicable to
Machining Operations**

Pollution Prevention/Water Conservation Method	Examples	Applicability
Prevention of Metal-Working Fluid Contamination		
Reduce contamination from tramp oil	Use coolant in hydraulic and other oil systems.	Applicable to most machines. In most cases, requires use of special fluid.
	Replace hydraulics with electrical systems.	Limited applicability. Practical only during major equipment overhaul.
	Machine maintenance.	Applicable to all machines. Should be performed at regularly scheduled intervals.
Reduce contamination from make-up water	Use deionized water for initial make-up of working fluid and to account for evaporative losses.	Applicable to all machining operations using a water-soluble fluid. Especially important in areas where the water supply is high in TDS.
Reduce contamination from sumps	Sterilize sumps during clean-out using steam.	Applicable to all machining operations. Especially important with large concrete sumps.
	Use metal inserts or coat walls of concrete sumps.	Applicable to in-ground concrete sumps.
Extension of Metal-Working fluid Life		
Raw material substitution	Use high quality fluids with needed "additive package."	Most machining operations can benefit from the use of high-quality fluids that can extend fluid life, while reducing bacterial growth, improving lubricity, reducing friction, and providing corrosion protection.

Table 15-7 (Continued)

Pollution Prevention/Water Conservation Method	Examples	Applicability
Equipment modification	Replace sump's air agitation with mechanical agitation.	Applicable to central sumps with air agitation.
	Install tramp oil removal device.	Limited mainly to external sumps.
Fluid Monitoring	Measure pH, coolant concentration, tramp oil concentration, and bacterial count weekly or more frequently.	Applicable to all machining operations. Larger operations can use data for statistical process control.
Metal-working fluid recycling	Use methods and technologies for removing fluid contaminants (e.g., filtration, centrifuge, pasteurization).	Simple filtration methods can be used by all machining operations. More sophisticated equipment is limited to larger operations.
	Recycle chip drainage.	Applicable to all machining operations. Requires clean handling and storage methods to prevent contamination.

Source: MP&M Site Visits, MP&M Surveys, Technical Literature.

Table 15-8

Pollution Prevention and Water Conservation Methods Applicable to Painting Operations

Pollution Prevention/Water Conservation Method	Examples	Applicability
Reduce the Quantity of Paint Entering the Water System		
Improve spray painting operating practices	Provide operator training to improve racking and positioning of parts to reduce over spray, assure proper selection of nozzle for efficient spray pattern, improve work scheduling and reduce clean-outs, improve housekeeping.	Applicable to all spray painting operations.
Improve paint transfer efficiency	Replace inefficient conventional compressed air spray equipment with high-velocity/low-pressure equipment.	Applicable to most existing spray painting operations using conventional equipment. Will require some retraining of operators.
Install gun cleaning station	Use gun-cleaning station to clean guns and lines. Can prevent spraying of cleaning fluid/paint into booth.	Applicable to most solvent-based painting operations.
Recycle Paint Booth Water		
Recycle paint booth water through solids removal	Use booth water maintenance system that removes paint solids. Applicable technologies include weirs, filters, and centrifuges.	Applicable to most water-wash booths. Usually requires treatment of booth water with chemicals to produce solids that can be separated from water.
Use Dry-Filter Booths		
Use dry-filter booths instead of water-wash booths	Convert existing water-wash booth to a dry-filter booth.	Applicable to booths with low to moderate paint usage. In cases of high paint usage, dry filters clog too quickly.

Source: MP&M Site Visits, MP&M Surveys, Technical Literature.

Table 15-9

**Pollution Prevention and Water Conservation Methods Applicable to
Cleaning Operations**

Pollution Prevention/Water Conservation Method	Examples	Applicability
Housekeeping and maintenance	Check the accuracy of temperature controls; remove sludge build-up from tanks, heat coils and temperature regulators; retrieve parts, racks, etc. dropped into the tanks; and check the integrity of tanks and tank liners.	Applicable to all cleaning operations.
Oil and suspended solids removal	Technologies used to remove oil and suspended solids from cleaning solutions, thereby extending the useful life span of the solutions (e.g., skimmers, coalescers, cartridge and membrane filters).	Suspended solids removal equipment (e.g., cartridge filters) are applicable to nearly all baths. The other types of equipment are applicable to most or all alkaline cleaning baths.
Dissolved solids removal	Various technologies and processes that remove dissolved metals from baths, including acid sorption, diffusion dialysis, and membrane electrolysis.	Applicable to acid and alkaline solutions that become contaminated with dissolved metal, usually due to etching of the basis metal.

Source: MP&M Site Visits, MP&M Surveys, Technical Literature.

16.0 GLOSSARY/LIST OF ACRONYMS

Act - The Clean Water Act.

Administrator - The Administrator of the U.S. Environmental Protection Agency.

Agency - U.S. Environmental Protection Agency (also referred to as “EPA”).

AWQC - Ambient Water Quality Criteria.

BAT - Best available technology economically achievable, as defined by section 304(b)(2)(B) of the Clean Water Act.

BCT - Best conventional pollutant control technology, as defined by section 304(b)(4) of the Clean Water Act.

BMP - Best management practices, as defined by section 304(e) of the Clean Water Act or as authorized by section 402 of the Clean Water Act.

BOD₅ - Five-day biochemical oxygen demand. A measure of biochemical decomposition of organic matter in a water sample. It is determined by measuring the dissolved oxygen consumed by microorganisms to oxidize the organic contaminants in a water sample under standard laboratory conditions of five days and 20EC. BOD₅ is not related to the oxygen requirements in chemical combustion.

BPT - Best practicable control technology currently available, as defined by section 304(b)(1) of the Clean Water Act.

CAA - Clean Air Act (42 U.S.C. 7401 *et seq.*, as amended *inter alia* by the Clean Air Act Amendments of 1990 (Pub. L. 101-549, 104 stat. 2394)).

CBI - Confidential Business Information.

CE - Cost effectiveness.

CFR - Code of Federal Regulations, published by the U.S. Government Printing Office. A codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.

COD - Chemical oxygen demand. A nonconventional, bulk parameter that measures the oxygen-consuming capacity of refractory organic and inorganic matter present in water or wastewater. COD is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test (see Method 410.1).

Contract Hauling - The removal of any waste stream from the facility by a company authorized to transport and dispose of the waste, excluding discharges to sewers or surface waters.

Control Authority - The term “control authority” as used in section 403.12 refers to: (1) The POTW if the POTW’s submission for its pretreatment program (§403.3(t)(1)) has been approved in accordance with the requirements of §403.11; or (2) the approval authority if the submission has not been approved.

Conventional Pollutants - The pollutants identified in section 304(a)(4) of the Clean Water Act and the regulations thereunder (i.e., biochemical oxygen demand (BOD₅), total suspended solids (TSS), oil and grease, fecal coliform, and pH).

CWA - Clean Water Act. The Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251 *et seq.*), as amended, *inter alia*, by the Clean Water Act of 1977 (Public Law 95-217) and the Water Quality Act of 1987 (Public Law 100-4).

DAF - Dissolved air flotation.

Direct Capital Costs - One-time capital costs associated with the purchase, installation, and delivery of a specific technology. Direct capital costs are estimated by the MP&M cost model.

Direct Discharger - An industrial discharger that introduces wastewater to a water of the United States with or without treatment by the discharger.

EEBA - Economic, Environmental, and Benefits Analysis of the Proposed Metal Products & Machinery Rule. This document presents the methodology employed to assess economic and environmental impacts and benefits of the proposed rule and the results of the analysis.

Effluent - Wastewater discharges.

Effluent Limitation - A maximum amount, per unit of time, production, volume, or other unit, of each specific constituent of the effluent from an existing point source that is subject to limitation. Effluent limitations may be expressed as a mass loading or as a concentration in milligrams of pollutant per liter discharged.

Emission - Passage of air pollutants into the atmosphere via a gas stream or other means.

End-of-Pipe Treatment (EOP) - Refers to those processes that treat a facility waste stream for pollutant removal prior to discharge.

EPA - The U.S. Environmental Protection Agency (also referred to as “the Agency”).

Facility - A place of business that conducts MP&M operations (also referred to as “site”).

Federally Owned Treatment Works (FOTW) - Any device or system owned and/or operated by a United States federal agency to recycle, reclaim, or treat liquid sewage or liquid industrial wastes.

FR - Federal Register, published by the U.S. Government Printing Office. A publication making available to the public regulations and legal notices issued by federal agencies.

FTE - Full time equivalents (related to the number of employees).

HAP - Hazardous air pollutant.

Hazardous waste - Any material that meets the Resource Conservation and Recovery Act definition of “hazardous waste” contained in 40 CFR Part 261.

Hexane Extractable Material (HEM) - A method-defined parameter (EPA Method 1664) that measures the presence of relatively nonvolatile hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases, and related material that are extractable in the solvent n-hexane. This parameter does not include materials that volatilize at temperatures below 85°C. EPA uses the term “HEM” synonymously with the conventional pollutant oil and grease (O&G).

ICR - Information Collection Request.

Indirect Capital Costs - One-time capital costs that are not technology specific and are represented as a multiplication factor that is applied to the direct capital costs estimated by the MP&M cost model.

Indirect Discharger - An industrial discharger that introduces wastewater into a POTW.

Influent - Wastewater entering a facility wastewater treatment unit.

LTA - Long-term average. For purposes of the pretreatment standards, average pollutant levels achieved over a period of time by a facility, subcategory, or technology option.

MACT - Maximum Achievable Control Technology (applicable to NESHAPs).

Metal Finishing Job Shop - A facility that owns 50 percent or less (based on metal surface area processed per year) of the materials undergoing metal finishing on site.

Minimum Level - The lowest concentration that can be reliably measured by an analytical method.

Mixed-Use Facility - Any municipal, private, U.S. military or federal facility which contains both industrial and commercial/administrative buildings at which one or more industrial sites conduct operations within the facility’s boundaries.

MP&M - Metal Products and Machinery Point Source Category.

NSCEP - EPA's National Service Center for Environmental Publications.
(<http://www.epa.gov/ncepi>)

NESHAP - National Emission Standards for Hazardous Air Pollutants.

New Source - As defined in 40 CFR 122.2 and 122.29, and 403.3(k), a new source is any building, structure, facility, or installation from which there is or may be a discharge of pollutants, the construction of which commenced for purposes of compliance with New Source Performance Standards and Pretreatment Standards for New Sources after the promulgation of the final rule under Clean Water Act sections 306 and 307(c).

NRMRL - EPA's National Risk Management Research Laboratory (formerly RREL - EPA's Risk Reduction Engineering Laboratory).

Noncontact Cooling Water - Water used for cooling which does not come into direct contact with any raw material, intermediate product, by-product, waste product, or finished product. This term is not intended to relate to air conditioning systems.

Nonconventional Pollutant - Pollutants other than those defined specifically as conventional pollutants (identified in section 304(a) of the Clean Water Act) or priority pollutants (identified in 40 CFR Part 423, Appendix A).

Nondetect Value - Samples below the level that can be reliably measured by an analytical method. This is also known, in statistical terms, as left-censored (i.e., value having an upper bound at the sample-specific detection limit and a lower bound at zero).

Nonprocess Wastewater - Sanitary wastewater, noncontact cooling water, and storm water. In relation to a mixed use facility, as defined in the MP&M effluent limitations guidelines and standards (40 CFR Part 438), nonprocess wastewater for this part also includes wastewater discharges from nonindustrial sources such as residential housing, schools, churches, recreational parks, and shopping centers, as well as wastewater discharges from gas stations, utility plants, hospitals, and similar sources.

Non-Water Quality Environmental Impact - An environmental impact of a control or treatment technology, other than to surface waters, such as energy requirements, air pollution, and solid waste generation.

NPDES - National Pollutant Discharge Elimination System, a federal program requiring industry dischargers, including municipalities, to obtain permits to discharge pollutants to the nation's water, under section 402 of the Clean Water Act.

NRDC - Natural Resources Defense Council.

NSPS - New source performance standards, under section 306 of the Clean Water Act.

OCPSF - Organic Chemicals, Plastics, and Synthetic Fibers Manufacturing Point Source Category (40 CFR Part 414).

Off Site - Outside the boundary of the facility.

Oil and Grease (O&G) - A method-defined parameter (EPA Method 413.1) that measures the presence of relatively nonvolatile hydrocarbons, vegetable oils, animal fats, (EPA nitrous 413.1) waxes, soaps, greases, and related materials that are extractable in Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane). This parameter does not include materials that volatilize at temperatures below 75°C. Oil and grease is a conventional pollutant as defined in section 304(a)(4) of the Clean Water Act and in 40 CFR Part 401.16. Oil and grease is also measured by the hexane extractable material (HEM) method (see Method 1664, promulgated at 64 FR 26315; May 14, 1999). The analytical method for TPH and oil and grease has been revised to allow for the use of normal hexane in place of Freon 113, a chlorofluorocarbon (CFC). Method 1664 (Hexane Extractable Material) replaces the current oil and grease Method 413.1 found in 40 CFR 136.

On Site - Within the boundary of the facility.

Operating and Maintenance (O&M) Costs - Costs related to operating and maintaining a treatment system, including the estimated costs for compliance wastewater monitoring of the effluent.

ORP - Oxidation-reduction potential.

Point Source Category - A category of sources of water pollutants.

Pollutant of Concern - Pollutant parameter identified in MP&M sampling data that met the following criteria: 1) the pollutant parameter was detected in at least three samples collected during the MP&M sampling program; 2) the average concentration of the pollutant parameter in samples of wastewater from MP&M unit operations and influents-to-treatment was at least five times the minimum level, or the average concentration of effluents-from-treatment wastewater samples exceeded five times the minimum level; and (3) the pollutant parameter was analyzed in a quantitative manner (i.e., analysis was not used only for screening purposes and was subject to quality assurance/quality control (QA/QC) procedures).

Pollution Prevention - The use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes. It includes practices that reduce the use of hazardous and nonhazardous materials, energy, water, or other resources, as well as those practices that protect natural resources through conservation or more efficient use. Pollution prevention consists of source reduction, in-process recycle and reuse, and water conservation practices.

Publicly Owned Treatment Works (POTW) - A treatment works as defined by section 212 of the Clean Water Act, which is owned by a state or municipality (as defined by section 502(4) of the Clean Water Act). This definition includes any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes, and other conveyances only if they convey wastewater to a POTW treatment plant. The term also means the municipality as defined in section 502(4) of the Clean Water Act, which has jurisdiction over the indirect discharges to and the discharges from such a treatment works (40 CFR 403.3).

PPA - Pollutant Prevention Act of 1990 (42 U.S.C. 13101 *et seq.*, Pub. L. 101-508, November 5, 1990).

Priority Pollutants - The 126 pollutants listed in 40 CFR Part 423, Appendix A.

Privately Owned Treatment Works (PrOTW) - Any device or system owned and operated by a private company that is used to recycle, reclaim, or treat liquid industrial wastes not generated by that company.

Process Wastewater - Any water that, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product. This includes wastewater from noncontact, nondestructive testing (e.g., photographic wastewater from nondestructive X-ray examination of parts) performed at facilities subject to MP&M effluent limitations guidelines and standards (40 CFR Part 438).

Production Normalized Flow (PNF) - Volume of wastewater per unit of production.

PSES - Pretreatment standards for existing sources of indirect discharges, under section 307(b) of the Clean Water Act.

PSNS - Pretreatment standards for new sources of indirect discharges, under sections 307(b) and (c) of the Clean Water Act.

RCRA - Resource Conservation and Recovery Act (PL 94-580) of 1976, as amended (42 U.S.C. 6901, *et seq.*).

SBREFA - Small Business Regulatory Enforcement Fairness Act of 1996 (P.L. 104-121, March 29, 1996).

SGP - EPA's National Metal Finishing Strategic Goals Program.

SIC - Standard Industrial Classification, a numerical categorization scheme used by the U.S. Department of Commerce to denote segments of industry.

Silica Gel Treated Hexane Extractable Material (SGT-HEM) - The freon-free oil and grease method (EPA Method 1664) used to measure the portion of oil and grease that is similar to total petroleum hydrocarbons. (Also referred to as nonpolar material (NPM)).

Site - A place of business that conducts MP&M operations (also referred to as “facility”).

SIU - Significant Industrial User. All industrial users subject to Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, subchapter N, and any other industrial user that: discharges an average of 25,000 gallons per day or more of process wastewater to the POTW (excluding sanitary, noncontact cooling, and boiler blowdown wastewater); contributes a process wastestream that makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant; or is designated as such by the control authority as defined in 40 CFR 403.12(a) on the basis that the industrial user has a reasonable potential for adversely affecting the POTW’s operation or for violating any pretreatment standard or requirement (in accordance with 40 CFR 403.8(f)(6)).

Source Reduction - Any practice that reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment prior to recycling, treatment, or disposal. Source reduction can include equipment or technology modifications, process or procedure modifications, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

Surface Waters - Waters including, but not limited to, oceans and all interstate and intrastate lakes, rivers, streams, mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, and natural ponds.

Semivolatile Organic Compound (SVOC) - A measure of semivolatile organic constituents performed by isotope dilution gas chromatography/mass spectrometry (GC/MS), EPA Method 1625. The isotope dilution technique uses stable, isotopically labeled analogs of the compounds of interest as internal standards in the analysis.

Technical Development Document (TDD) - Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products & Machinery Point Source Category.

Technology in Place (TIP) - Refers to those technologies that the Agency considered to be installed and operating at a model site in 1989 (for Phase I questionnaire recipients) or 1996 (for Phase II questionnaire recipients).

Total Annualized Cost (TAC) - Cost calculated from the capital and annual costs assuming a 7 percent discount rate over an estimated 15-year equipment life.

Total Organic Carbon (TOC) - A nonconventional bulk parameter that measures the total organic content of wastewater (EPA Method 415.1). Unlike five-day biochemical oxygen

demand (BOD₅) or chemical oxygen demand (COD), TOC is independent of the oxidation state of the organic matter and does not measure other organically bound elements, such as nitrogen and hydrogen, and inorganics that can contribute to the oxygen demand measured by BOD₅ and COD. TOC methods utilize heat and oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants to convert organic carbon to carbon dioxide (CO₂). The CO₂ is then measured by various methods.

Total Organics Parameter (TOP) - A parameter that is calculated as the sum of all quantifiable concentration values greater than the nominal quantitation value of the organic pollutants listed in the Appendix B to 40 CFR Part 438. These organic chemicals are defined as parameters at 40 CFR 136.3 in Table 1C, which also cites the approved methods of analysis or have procedures that have been validated as attachments to EPA Methods 1624/624 or 1625/625.

Total Capital Investment (TCI) - Total one-time capital costs required to build a treatment system (i.e., sum of direct and indirect capital costs).

Total Petroleum Hydrocarbons (TPH) - A method-defined parameter that measures the presence of mineral oils that are extractable in Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane) and not absorbed by silica gel. The analytical method for TPH and oil and grease has been revised to allow for the use of normal hexane in place of Freon 113, a chlorofluorocarbon (CFC). Method 1664 (Hexane Extractable Material) replaces the current oil and grease Method 413.1 found in 40 CFR 136. (Also referred to as nonpolar material (NPM)).

Treatment Effectiveness Concentration - Treated effluent pollutant concentration that can be achieved by each treatment technology that is part of an MP&M regulatory option.

Treatment, Storage, and Disposal Facility (TSDF) - A facility that treats, stores, or disposes of hazardous waste in compliance with the applicable standards and permit requirements set forth in 40 CFR Parts 264, 265, 266, and 270.

TRI - Toxic Release Inventory.

TSCA - Toxic Substances Control Act (15 U.S.C. 2601 *et seq.*).

TSS - Total suspended solids. A measure of the amount of particulate matter that is suspended in a water sample, obtained by filtering a water sample of known volume. The particulate material retained on the filter is then dried and weighed (see Method 160.2).

TTO - Total toxic organics, as defined in the Metal Finishing effluent guidelines (40 CFR Part 433).

TWF - Toxic weighting factor. A factor developed for various pollutants using a combination of toxicity data on human health and aquatic life and relative to the toxicity of copper. EPA uses

toxic weighting factors in determining the amount of toxicity that a pollutant may exert on human health and aquatic life.

U.S.C. - The United States Code.

Unit Operations - All processes performed on metal parts, products, or machines in their manufacture, maintenance, or rebuilding.

Variability Factor - A variability factor is used in calculating a limitation to allow for reasonable, normal variation in pollutant concentrations when processed through well designed and operated treatment systems. Variability factors account for normal fluctuations in treatment. By accounting for these reasonable excursions about the long-term average, EPA's use of variability factors results in limitations that are generally well above the actual long-term average.

Volatile Organic Compound (VOC) - A measure of volatile organic constituents performed by isotope dilution gas chromatography/mass spectrometry (GC/MS), EPA Method 1624. The isotope dilution technique uses stable, isotopically labeled analogs of the compounds of interest as internal standards in the analysis.

Wet Air Pollution or Odor Pollution Control System Scrubbers - Any equipment using water or water mixtures to control emissions of dust, odors, volatiles, sprays, or other pollutants.

Zero Discharger - A facility that does not discharge pollutants to waters of the United States or to a POTW. Also included in this definition are discharge or disposal of pollutants by way of evaporation, deep-well injection, off-site transfer to a treatment facility, and land application.